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BY- JOHNSON, LLOYD K. AND OTHERS

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RESEARCH STUDIES RELATED TO THE TEACHING AND LEARNING OF
SCIENCE ARE REVIEWED IN THIS BOOKLET. STUDIES COMPLETED
BETWEEN 1959 AND 1963 ARE GROUPED INTO CATEGORIES OF
ELEMENTARY, HIGH SCHOOL, AND COLLEGE SCIENCE. FOR EACH
CATEGORY A BRIEF INTERPRETIVE SUMMATION AND ANALYSIS OF THE
RESEARCH IS PRESENTED IN THE CONTEXT OF RELATED ITEMS OF
RESEARCH. STUDIES COMPLETED BETWEEN 1959 AND 1963 ARE LISTED
IN A BIBLIOGRAPHY, WHILE ABSTRACTS FOR SELECTED STUDIES ARE
ALSO INCLUDED. A CHAPTER CONTAINING GUIDELINES AND
RECOMMENDATIONS FOR FUTURE RESEARCH IS INCLUDED. THIS
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Bulletin 1965, No. 10

Research IN THE Teaching of Science

Analysis and Selected Abstracts: 1959-61

Studies Completed: 1959-63

by

LLOYD K. JOHNSON
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U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION

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Foreword

THIS BULLETIN continues a cooperative project of the U.S. Office of Education and the National Association for Research in Science Teaching for collecting and summarizing research in the teaching of science. The summaries of research completed from 1950 through 1956 were published on an annual basis. The last of these bulletins, which summarized the research for 1956-57, was published in 1960. At that time a change to biennial reports was instituted. The first of these reports, covering research completed between July 1957 and July 1959, was published in 1962. The present publication is the second of the series of biennial reporting. The abstracts presented in this report were selected from studies known to have been completed between 1959-61, but the bibliographic list of studies also includes investigations which have been completed between 1961-63.

Three committees of the National Association for Research in Science Teaching have contributed to the preparation of this bulletin:

Elementary.—John G. Navarra, *Chairman*; Dorothy Alfke, J. Myron Atkin, Harry Milgrom, and Albert Piltz. (Dr. Alfke agreed to serve as a member of the committee. However, her participation in the project was terminated by acceptance of an educational mission abroad.)

Secondary.—John M. Mason, *Chairman*; Thomas G. Aylesworth, Shirley Brehm, Frederic B. Dutton, T. Wayne Taylor, and William J. Walsh.

College.—Joseph D. Novak, *Chairman*; Raymond Hahn, Arnold Lahti, J. Stanley Marshall, and Robert MacCurdy.

This publication has been made possible through the cooperation of those who prepared and submitted abstracts or suggested sources of studies. The assistance of these persons and the committee members is gratefully acknowledged.

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Introduction

DURING RECENT YEARS science and technology have taken on a vital role in Western culture. With an unprecedented increase in the rate of expansion of scientific knowledge, new demands have been placed on the science programs in our schools. The goals of science education are being reexamined, new courses developed, and new instructional techniques introduced.

In this setting, research in the teaching of science takes on added significance. The fact that science programs are changed does not necessarily mean that they are improved. Carefully planned research is a keystone in plans for improving science instruction. Thoroughgoing research in the philosophy and objectives of science education, the nature of the learning process and its relation to inquiry and concept development, and the evaluation of teaching techniques is needed to assure that innovation will contribute to the improvement of existing procedures.

This series of publications should contribute to the research effort in science education in a number of ways. First, it shows the aspects of science teaching in which research has been completed. Second, the reader can determine the types of problems researched in each of these general aspects. Finally, and by no means least in importance, the reader will note fields of investigation and problems in which research is lacking and is sorely needed.

In preparing the reviews of research, the National Association for Research in Science Teaching and the U.S. Office of Education have attempted to obtain complete coverage of all science education research completed during the biennium. The committees of the association and the specialists for science in the Office of Education fully screened the July 1959 to July 1961 issues of the journals generally publishing research in the teaching of science. After published reports were located, the Office of Education sent an inquiry sheet to the author asking for an abstract of the study. A sample of the inquiry sheet and abstract form is carried in the appendix.

The collection of unpublished research followed a somewhat different procedure. Once a year, or twice in the biennium, the Office of Education mailed abstract forms to more than 1,200 colleges and universities that offered advanced courses in science education. As in

published research, the responsibility for preparing the abstract of a study was assumed by the author. Completed abstracts were returned to the Office of Education where they were cataloged and forwarded to the appropriate committee for analysis and evaluation.

The studies reported in this volume have been examined by at least three committee members and one or more specialists at the Office of Education. The criteria used in evaluating the studies were originally prepared by a NARST committee of which Francis D. Curtis was chairman. These criteria were later adopted by the association. The criteria, originally published under the title "What Constitutes a Research Investigation in Science Education,"¹ are the following:

In order to be classed as a research investigation, a study must satisfy the criteria in one of three categories: A. Experimental, B. Analytical, or C. Synthetic.

A. Experimental studies include comparisons of learning under different methods or conditions of teaching and all other investigations that involve pupils in one or more types of learning situations. They are characterized generally by the following steps or techniques:

1. A statement of a carefully and specifically defined and delimited problem.
2. A thorough study of the literature appertaining to the problem, for the purpose of determining the need for the study and its possible contribution.
3. The development and use of an appropriate experimental design.
4. The collection of data and their treatment by appropriate statistical techniques.
5. A presentation of the findings and of the conclusions that seem justified by them.

B. Analytical studies are systematic attempts to determine from published materials, cooperating teachers, field studies, and other sources such factors as the aims that govern or that should govern the teaching, subject-matter elements taught, the relative importance of topics, and facilities needed for teaching. Analytical studies are characterized generally by the following:

1. A statement of a carefully and specifically defined and delimited problem.
2. A thorough study of the literature appertaining to the problem, for the purpose of determining the need for the study and its possible contribution.
3. A selection or invention of a technique appropriate to the problem and also one that provides means by which the validity and the reliability of analysis may be determined and maintained.

¹ *Science Education*, 37: 53-54, February 1953.

4. A presentation of the findings and of the conclusions that seem justified by them.

C. Synthetic studies are investigations in which various curricular materials, resource-use data, instructional suggestions, references, and aids to teaching are brought together into a unified pattern to be helpful in an educational situation. Synthetic studies are characterized generally by the following steps or techniques:

1. A statement of a carefully and clearly defined need or objective.
2. The development of criteria for maintaining selectivity in the use of materials and the consistent use of the criteria in thorough studies of materials appertaining to the need or objective.
3. The development of a practical pattern or technique for organizing the materials that met the criteria.
4. The preparation of a substantial publication that summarizes the results of the studies.

The selection of abstracts published in the present bulletin reflects the pooled judgments of the committees and the cooperating specialists for science. They assume full responsibility for the placement of the studies at the elementary, secondary, or college level and for categorizing the studies according to field of investigation.

The reader should be reminded that the U.S. Office of Education and the National Association for Research in Science Teaching are in no way responsible for the subjects selected for research, for the design of the studies, or for the results. The Office and the association can collect, abstract, and disseminate only the research completed. They can improve it only as the studies are constructively criticized.

Every study located has been included in one of the three bibliographies. However, space limitations preclude publishing abstracts of all the research completed during the biennium. It was not possible to obtain abstracts of certain studies, and thus the committees had no opportunity to review them. It is probable that much of this research, even though it has not been abstracted, will be of value in science education studies.

Research Studies in Elementary School Science

INCLUDED IN THIS SECTION are an analysis of research in elementary school science teaching, an interpretation of this research, abstracts of selected studies of 1959-61, and lists of studies completed between 1959 and 1963. The total volume of research reported has increased somewhat from the past biennium, 1957-59. This increase in the number of studies may be an indication of a resurgence of interest in elementary school science.

Analysis

The categories under which the investigations are reported in this section were adopted by the National Association for Research in Science Teaching as areas in which research studies are needed. (See p. 142.) The same classification scheme has been followed in the secondary and college sections with the hope that the reports will be comparable. In what areas has research been conducted? Where is further research at each school level needed?

Studies Related to Public Policy.—A study by *Charles* compared achievement of fifth-grade pupils coming from different cultural backgrounds. He found that the children of the minority ethnic groups were retarded approximately 2 years in science achievement and, as may be expected, were significantly over age for their grade. This study has general implications for schools with heterogeneous student bodies.

Studies Related to Curriculum.—Five of the 16 studies that have been abstracted have been assigned to this classification. *Alford* sought to discover the science interests of children in the upper elementary grades, particularly to determine any changes of interests related to recent developments in space flight, atomic energy, and mass communications media. Marked differences were found in the interests expressed by the boys from those expressed by the girls. The fifth- and sixth-grade girls and boys reported different interests than did those in the fourth grade. More rural and smalltown children were interested in science than those in the larger city schools.

Teachers encountered many difficulties in science instruction, such as lack of equipment, books, space, and time. They reported an average of 2.11 science courses at the college level and expressed a need for a stronger science background.

Haber evaluated the effectiveness of units on magnetism and electricity taught to third- and sixth-grade students. These units, selected from a newly developed course of study, were taught to two experimental classes at each grade level and their performance was compared to that of matched control classes. Significant differences in favor of the experimental groups were reported on both a posttest and a retention test given 1 month after completion of the unit.

The results of the initial tests of a course in modern astronomy for fourth-, fifth-, and sixth-grade children were reported by *Atkin*. The course was developed by professional astronomers and taught to pupils with intelligence quotients over 105. The general procedure followed was that of "discovery" of major relationships and principles as they emerged from discussions which began with a presentation of factual materials. The children displayed high interest during the class sessions and were able to conceptualize many topics. However, teachers indicated uncertainty about their ability to teach the concepts of modern astronomy.

Busch developed a field guide for enriching the New York City course of study for elementary science. The illustrated guide lists 35 resources selected from a preliminary list of 98 common to 15 typical schools in the city.

In an investigation of the effect of three different organizational patterns of teaching science at the seventh- and eighth-grade levels, *Dameron* found no significant differences between the three groups. It should be noted that the average scores made by the participants on both pretests and posttests ranked at the 98th percentile of the groups selected in standardizing the test.

Studies Related to Learning.—Two studies, one by *Sister M. Sanctia Chotkowska* and the other by *Oakes*, were concerned with factors which influence the learning of science. The first was an investigation of incidental science learnings of sixth-grade pupils as related to several factors including achievement in health and safety, intelligence, and verbal ability. The pupils correctly identified more than 50 percent of the concepts sampled. Substantial relationships were found between the acquisition of incidental science learnings and the factors listed above.

Oakes measured the contribution of intelligence, interests, aptitudes, previous academic achievement, reading level, and certain personality

variables to the achievement of gifted seventh-grade pupils and determined a battery of tests for predicting success in general science.

Studies Related to Methods.—Both *Koester* and *Roossinck* attacked the problem of reading of science materials. *Koester*, who used sixth-grade children as subjects, found that the purpose of reading had no significant effect on the rate of initial reading. Fast readers were not necessarily the best readers in terms of comprehension. *Roossinck* investigated reading procedures used by scientists and compared them with those of sixth-grade pupils. The scientists' reading time was significantly less when reading for the main idea than when reading for sequence. Some of the reading practices of the scientists differed from those the children believed ideal readers would use.

Practices in using television as a teaching device were investigated in three studies. *Garry* reported that groups using television in combination with other procedures had statistically significant differences in science information and vocabulary achievement over the control groups which received television instruction only. No significant differences were found, however, in scientific reasoning ability or interest in science.

Schwarzwalder's findings indicated that higher student achievement results from a combination of one technique using a television team production effort and one technique using the teacher's effort. It appears that television production facilitates the effect of the teacher's effort.

Frazier and *Evans* tested the effectiveness of two-purpose television programs in contributing to both teacher and pupil learning. The teachers increased their feeling of competency in handling elementary school science, especially in the area of physical science. Pupil interest was high, and significant growth in problem-solving behavior was noted, even though there was no significant growth in achievement.

Studies Related to Teacher Education.—Several of the studies reported in other categories have implications for teacher education. This is particularly true of the *Frazier* and *Evans* investigation of the use of television.

Victor sent a questionnaire to 117 elementary school teachers to determine why teachers are reluctant to teach science. Over 80 percent had taught 4 or more years and 65 percent for a decade or longer, so lack of experience could hardly be a contributing factor. They reported that their reluctance was because of the unfamiliarity of the subject and embarrassment in being unable to answer pupils' questions. Three-fourths of the teachers, incidentally, had taken less than 2 years of science at the college level.

Zaffaroni studied pupil-teacher interaction in planning science experiences, identifying the roles of authority, laissez-faire, and counselor for the teacher. The role of the counselor produced the highest quality of interaction among the group. Records of problem-solving situations indicated that interaction reached a higher level when unexpected problems occurred.

Studies Related to Evaluation and Research Design.—Only one study was assigned to this classification. *Trexler* compared children's testimony about their conservation behavior and their observed conservation behavior. The correlation between the two was too low to suggest that children's testimony could be relied upon to ascertain their actual behavior. Personal factors such as IQ, sex, academic achievement, and home background did not appear to be significantly related to their behavior.

Interpretation

The studies related to science education in the elementary school deal with a variety of problems. Several dealt with the development and teaching of curriculum materials in such areas as electricity, magnetism, astronomy, and conservation. Others dealt in a more general way with how children learn science principles and concepts. Some attention has been given to how children make use of science concepts as intellectual tools for problem solving. However, this aspect of science education has not been dealt with in depth.

The concern of researchers about ways that various resources can effectively supplement the teacher is reflected in several of the studies. Ways of using television, for example, are now available both for teaching science to children and for inservice education of teachers. It has been demonstrated that community resources can be identified and organized to supplement the science curriculum in effective ways. At a time when more and more science equipment and apparatus is being designed for the elementary school, there were no studies reported that focused specifically on the relative merits of the materials or ways of using them.

Several major issues or concerns are currently preoccupying the thoughts of persons working on curriculum materials for science in the elementary schools. The studies reported here bear in varying degrees on these issues. One issue, for example, is whether children must study science through a carefully articulated series of science experiences based on a continuous and developmental program of science concepts. It is not a question of incidental science learnings as opposed to well-planned science learnings, but one of having children follow a highly structured curriculum as against a more oppor-

tunistic selection of topics and problems. Answering this question requires long-range study which is beyond the resources and time of the typical graduate student.

Another major issue concerns methods of teaching science. By planning many ways to engage children in investigations and inquiries where they use, to the best of their ability, the kinds of methods and skills used by scientists, will they successfully achieve the objectives of science education? Many people believe that the answer is *yes*. But is good science education something more or something different than providing opportunities for children to be like scientists? The study by *Trexler* bears on this question. If we are seeking to develop certain behavioral objectives as a purpose of science education, are the methods used compatible with the outcomes desired? There is a need for a series of studies of the teaching methods used in relation to desired outcomes in science. *Zaffroni* approached this through a study of interaction of teachers and pupils, but again, some long-term studies are needed which may be beyond the resources of single researchers.

The studies reported make a contribution to certain aspects of the total problem of improving science education in the elementary school. The studies, in most instances, are the first research endeavor of candidates for the master's and doctoral degrees, and as such have been completed with marginal time, personnel, financial, and research resources. The need for reexamining research findings and developing new techniques appropriate to emerging problems becomes more and more urgent with changes in school situations, instructional goals, and teaching methods.

Selected Abstracts—1959-61

ALFORD, GENEVIEVE GARRETSON. An Analysis of Science Interests of Selected Children and an Identification of Problems Encountered by the Teachers of These Children in Science Instruction.

Problem.—To discover the scientific interests of boys and girls in the upper elementary grades; to reveal any changes in interest characterized by space flight, atomic energy, and increased mass communication media; to determine science interest differences by sex, grade level, and geographic location. Also to attempt to identify instructional problems encountered by teachers.

Procedures.—In a selected area in Texas in 1958-59, interest sheets, devised to discover the science interests of children in grades 4, 5, and 6, were given to 3,348 boys and girls. Ninety-one classroom teachers received a questionnaire to elicit instructional problems, use of community resources, college level of science background of teacher, and need for additional training in science.

Findings.—All children indicated an interest in all phases of astrophysical science, earth sciences, the ocean, animal life, and particularly in television, radio, and radar. Over 30 percent of the boys indicated interest in jets, airplanes, motors, and electronics, followed by slightly less preference for space flight, animal life, astronomy, and the earth's surface.

In contrast, more than 30 percent of the girls indicated high interest in astronomy and in animal and plant life. Slightly fewer girls showed interest in the other science areas. The girls in

the fifth and sixth grades showed greater interest in the human body and in health and disease than did the other pupils. The fifth- and sixth-grade boys reported interest in the solar system, rocks and minerals, and motors to a greater extent than did those in the fourth grade. More rural and small-town boys and girls were interested in science than those in the larger city schools.

Teachers encountered many difficulties in science instruction, such as lack of equipment and materials, lack of books, lack of space, and lack of time. A need for better science background was expressed by the teachers, even though they had taken an average of 2.11 science courses at the college level. Many indicated a desire for some type of training program in elementary science. A need for more adequate utilization of community resources was noted from the study.

ATKIN, J. MYRON. Teaching Concepts of Modern Astronomy to Elementary School Children.

Problem.—To assess children's reactions to the study of certain science topics deemed basic to modern astronomy by interest in content after the first lesson, and mastery of the content.

Procedures.—After reviewing children's textbooks and trade books covering astronomy content, professional astronomers listed topics and problem areas viewed as fundamental in the field. Classroom trials through discussion techniques preceded the development of instructional materials.

The initial testing was carried on in grades 4, 5, and 6 with brighter-than-average youngsters, those with IQ's over 105. Twenty-five sessions of 45 minutes each were conducted in each of four different classroom situations. The general teaching technique was that of "discovery" of major relationships and principles as they emerged from discussions which began with factual material. Every class session was recorded on tape for analysis later. Reports from parents and the regular classroom teachers were evaluated, and classroom recordings were studied.

Findings.—There was clear evidence of high interest from the children during the astronomy sessions, and they were able to conceptualize many significant topics with comprehension. While teachers indicated uncertainty about their ability to teach the concepts of modern astronomy, this discovery method of teaching concepts of modern astronomy seems to be feasible. Boys tended to participate more freely than girls in the discussions.

BUSCH, PHYLLIS. An Urban Field Guide for the Enrichment of the New York City Course of Study in Science for the Elementary Schools: Grades K-6 (Parts I and II).

Problem.—To develop a guidebook for use by elementary school teachers as a reference for short science field trips in the immediate outdoor environment of city schools.

Procedures.—A comprehensive list of science topics used in the New York City course of study was determined from the reports of seven committees established by the Board of Education. Explorations for outdoor science enrichment facilities were carried on in 15 "typical" schools, 3 in each borough, and lists of resources were compiled. A preliminary list of 98 resources common to 90 percent of the schools resulted. These 98 re-

sources were further verified by exploring the outdoor environments of three additional schools in each borough. The following criteria were used to determine the suitability of each resource: (1) Safety of area, (2) availability of facility to public, (3) proximity of area, (4) suitability of facility within the seven science areas, (5) time requirement for total experience, (6) meaningfulness of experience for children in grades K-6, and (7) usefulness of resource for problem-solving experience. Only those resources judged to be *good* or *excellent* in each of the criteria were finally considered.

Findings.—Thirty-five resources were selected to be published in the guidebook which was illustrated by photographs of the facilities.

CHARLES, CAROL M. (Mr.). The Indian Child's Status in New Mexico's Public Elementary School Science Programs.

Problem.—To determine the status of science achievement of Indian children at the fifth-grade level and to investigate certain factors related to this status.

Procedures.—All fifth-grade pupils in selected public schools in New Mexico participated in the study. An urban Anglo group of 78 pupils served as a comparative group. The instruments used to collect data were National Achievement Tests, Elementary Science, grades 4-6; the Culturally Biased Science Test (constructed by the investigator); the Gates Reading Survey, grades 3-10; and the Otis Quick Scoring Intelligence Test, Alpha. Personal data were obtained from school records.

Findings.—The minority ethnic groups were retarded approximately 2 years in science achievement. In addition to academic retardation, pupils in these groups were significantly over age for grade. Compared to a mean age of 11 years for the Anglo comparative group,

the mean age of the others ranged from 12 years to 13 years, 7 months.

CHOTKOWSKA, SISTER M. SANCIA. An Investigation of Incidental Science Learnings With a Study of Their Relationship to Certain Factors.

Problem.—To measure the amount of incidental science learnings acquired by pupils without formal instruction in science and the relationship between such learnings and certain learning factors indicated below.

Procedures.—Sixth-grade pupils of the Catholic elementary schools of New York City were the subjects of the investigation. Six hundred of the 1,220 cases surveyed and tested were selected at random for study. Data for the study were obtained from standardized tests and a questionnaire. Tests were utilized to procure data on the acquisition of incidental science learnings; health and safety achievement; and the genetic factors of general intelligence, and numerical and verbal ability. Responses to the questionnaire supplied data for the following activating factors in the use of (1) mass media promoting science learnings, (2) community resources promoting science learnings, and (3) science information obtained from individuals outside of school. Statistical techniques were applied to data relevant to mental and chronological ages of subjects, to data obtained from achievement tests, and to questionnaire data relative to activating factors. They included analysis of variance, *t*-tests, the Pearson product-moment method, chi-square tests, and quadriserial correlation analysis.

Findings.—When the subjects were classified according to borough, each group correctly identified more than 50 percent of the science concepts sampled on the science test. The mean score of the boys on the science test was significantly higher than that of the girls. They identified more concepts in all areas meas-

ured by the science test. Patterns of substantial relationships were present between acquisition of incidental science learnings and achievement in health and safety, general intelligence, and verbal ability. More boys than girls indicated that they read science books, viewed television programs about science, and visited museums *very often or sometimes*.

DAMERON, JOSEPH D. A Study of the Science Achievement Test Scores of Eighth-Grade Pupils in Selected Junior High Schools.

Problem.—To evaluate the level of science achievement as evidenced by eighth-grade pupils in three different organization patterns for science instruction in junior high schools.

Procedures.—Seven midwestern junior high schools with a total of 1,495 eighth-grade pupils were selected for the investigation. Three organizational patterns for science instruction level characterized the schools: (1) the common learnings program (unified studies or core), including science as a function of the program along with English and social studies in both the seventh and eighth grades; (2) the conventional science class, taught daily as a separate subject for two semesters, one semester in the seventh grade and the second in the eighth grade; (3) the conventional science class of two semesters in the eighth grade, pupils in this group having had no formal science instruction in the seventh grade. The testing program included an intelligence test and a recently published science achievement test which was used as both a pre- and posttest. These data were compared by analyses of variance and covariance.

Findings.—The average converted science scores for the seven junior high schools ranked at the 98th percentile of the schools used in establishing norms for the science test, both on the pre- and posttest. There were no significant differences in mean science achievement test

scores among the three patterns of instruction.

FRAZIER, ALEXANDER, and LEWIS D. EVANS. Testing the Effectiveness of Two-Purpose Television Programs in Contributing to Both Teacher and Pupil Learning.

Problem.—To explore the effectiveness of two-purpose television programs in contributing to increased teacher understanding of elementary science and in stimulating pupil activity in this field.

Procedures.—Evaluation of the programs was determined by (1) attitude questionnaires given to teachers before and after the series, (2) Sequential Tests of Educational Progress given to fourth-grade pupils to measure aspects of thinking and the ability to use science information in situational problems; (3) program evaluations by teachers; (4) evaluation of complete series by teachers; (5) principal and supervisor reactions; and (6) personal interviews with 20 teachers selected at random.

Findings.—Teachers significantly increased their feeling of competency in handling elementary classroom science especially in the physical science area, and responded to the idea of receiving similar consultative service in other areas. Teachers reported that pupil interest was high, and significant growth in problem-solving behavior was noted, although the STEP test revealed no significant growth in achievement.

GARRY, RALPH J. Report of Research on the Integration of Science Teaching by Television Into the Elementary School Program.

Problem.—To study the effects of teacher training, method of presentation, teaching method, and pupil activity upon the achievement, interests, attitudes, and scientific reasoning ability of fifth-grade pupils studying natural science by television.

Procedures.—About 2,600 fifth-grade pupils in 90 classes in and around Boston viewed a series of 30 half-hour natural science programs produced by the Massachusetts Audubon Society and designed to develop understanding of the relationship of all living things to their environment. Eighteen classes (control) received only television instruction. Seventy-two classes (experimental) received televised instruction with various combinations of conditions: (1) TV instruction to initiate a unit of study versus TV instruction to terminate the unit; (2) teacher use of an extensive study guide versus no study guide; (3) common assignments for all class members versus individual projects; and (4) teachers especially trained for this project versus teachers with no special workshop. Effects were measured by specially constructed tests on science information, vocabulary, achievement, reasoning; interest inventory, activity checklist, TV viewing checklist; and two attitude scales.

Findings.—(1) Experimental classes had large, statistically significant differences in science information and vocabulary achievement over the control group. (2) No significant differences were found between the two groups in scientific reasoning ability or interest in science. (3) The main experimental effects taken singly produced no statistically significant differences between experimental classes, but significant differences on certain interactions were obtained. (4) No significant differences in pupil achievement were found between groups having or not having teachers with special workshop training. (5) Where TV programs were used as a terminal activity, greater learning occurred when the class assignments were made by the teacher and were common to all; where TV was used to initiate a program, the followup activity for an optimum combination was individual project assignments. (6) Classes taught by teachers with brief outlines, and those taught by teachers with comprehensive study guides achieved similar

results. (7) Pupil attitudes toward science and scientists did not change readily. (8) Children of high initial interest and those of high intelligence tended to lose interest as the school year progressed; the more intensive the schoolwork, the greater the loss. (9) Variations in skill among teachers yielded considerable differences in learning.

HABER, LOUIS. An Experimental Study To Measure the Effective Learning in a Selected Unit of a Proposed Course of Study in an Elementary School Science Program.

Problem.—To evaluate the effectiveness of a proposed course of study in an elementary school science program by measuring the effective learning in a selected unit of the course of study.

Procedures.—Eight classes, four for the experimental and four for the control groups, were selected from the public elementary schools of White Plains. Each group included two third-grade and two sixth-grade classes. The groups were equated by age, sex, mental ability, reading ability, prior knowledge of magnetism and electricity, and on the science and experiential backgrounds of the teachers.

Pre- and posttests were constructed by the investigator and validated by analyses of textbooks and courses of study. The tests were then administered to third- and sixth-grade classes and refined on the basis of item analyses. The pretest was administered to all pupils prior to and the posttest immediately following study of the unit on magnetism and electricity. A retention test was given 1 month after the posttest. Analysis of variance was used to test the significance of the differences between the means of the groups.

Findings.—The presence of a highly significant difference between the experimental and control groups indicated that the proposed course of study in science

was of great value in promoting effective learning in the area of magnetism and electricity. There was greater retention, as well as more effective learning, when instruction followed the proposed course of study in the selected unit than when the present method was followed. The proposed course of study met the needs of students of high and low mental and reading ability, as well as those of average ability.

Recommendations.—Other units of the proposed course of study should be evaluated prior to its adoption and use. Effective learning in the selected unit of this study should be measured by using other evaluative measures—such as teacher judgment, observed changed behavior, changes in scientific attitudes—to supplement the tests used in this study.

KOESTER, PAUL WILLIAM. Reading Science Materials for Two Specific Purposes at the Sixth-Grade Level.

Problem.—To investigate the following relationships which existed (1) among measures (one comprehension and three rate scores) of ability to read expository science material for a specific purpose; and (2) among measures of purposeful reading (comprehension and rate scores) and measures of intelligence, science achievement, general reading abilities, reading for problem solving in science, and reading behaviors associated with purposeful reading.

Procedures.—Fifty students in two sixth-grade classes in the same school were divided into two equated groups on the basis of IQ scores. Standardized tests were administered to both groups to obtain measures of general reading abilities, science achievement, and ability to read for problem solving in science. Two tests of purposeful reading called *Purposeful Reading of Science Materials* were developed. Each consisted of the same 20 different expository science passages all describing how to perform an experiment and explaining how a par-

ticular phenomenon occurred. Each passage was followed by two multiple-choice items. Group A was instructed to read to understand the step-by-step directions and Group B to read to find the best explanation for an event. Two passages were read daily for 10 days. The tests provided a comprehension score and three rate scores. The *t*-test was used to compare the mean scores of the equated groups.

Findings.—(1) The purpose of reading did not significantly affect the rate of initial reading. (2) The fast readers were not necessarily the best readers in terms of comprehension. (3) Readers with high nonverbal intelligence scores tended to have high comprehension scores on the tests of purposeful reading. Measures of intelligence were not good predictors of rate. (4) Readers with high science achievement scores tended to achieve best in purposeful reading comprehension but not in reading rate. (5) Readers who excelled on one test of reading comprehension excelled in other reading comprehension tests. (6) The superior reader in terms of comprehension may not be the fastest reader. (7) Students who read rapidly for one purpose may not be fast readers when reading for other purposes. (8) Reading rate, strategy, and accompanying behaviors are influenced by the purpose of reading. (9) The sixth-grade readers tended to manifest rigidity in reading procedures, starting with the first word and reading word for word. (10) The sixth-grade pupils were confused as to what specific behaviors characterized an effective purposeful-reading pattern. This confusion was shown by the discrepancies of ideal reading behaviors. The superior readers in the study were less sure of what practices constitute superior reading procedures than were the inferior readers.

OAKES, FREDERICK, JR. The Contribution of Certain Variables to the Academic Achievement of Gifted Seventh-Grade Students in an Ac-

celerated General Science Curriculum.

Problem.—To determine the contribution of intelligence, interests, aptitudes, previous academic achievement, reading level, and certain personality variables to the academic achievement of gifted seventh-grade junior high school students in an accelerated general science curriculum.

Procedures.—The Read General Science Test, Form AM; the Iowa Tests of Basic Skills; the Kuder Preference Record, Form CH; the Gordon Personal Profile; the Gordon Personal Inventory; the Differential Aptitude Tests, Form A; and the California Short-Form Test of Mental Maturity were administered to 52 gifted seventh-grade students participating in an accelerated general science curriculum. A rating scale was made for each student by the teachers. The criterion measure of success in the accelerated program was the Read General Science Test, Form BM.

The data were treated as follows: coefficients of correlation (Pearson *r*), between the criterion and each of the variables were calculated; the significance of each obtained correlation coefficient was determined; the significantly correlating variables were subjected to the *F*-test to determine whether the criterion regressed linearly upon each of these variables; the Wherry-Doolittle Test Selection Method was used to select the most efficacious battery of tests that correlated significantly with, and were linearly related to, the criterion; the multiple regression equation in score form was calculated for the tests selected by the Wherry-Doolittle Method.

Findings.—High scores on the criterion were associated with high scores on the Composite Iowa Tests of Basic Skills; the Mechanical and Social Service interest scales of the Kuder Preference Record; the Verbal Reasoning, Space Relations and Mechanical Reasoning Tests of the Differential Aptitude Tests; and the Read General Science Test, Form A.

(correlation at the 0.01 level of confidence) and with the California Short-Form Test of Mental Maturity—Language Factors; the Iowa Tests of Basic Skills—Reading Score, the Scientific Interest Scale of the Kuder Preference Record; and the Numerical Ability Test score of the Differential Aptitude Tests (correlation at the 0.05 level of confidence). The regression of the criterion on the reading score of the Iowa Tests of Basic Skills was found to be nonlinear, thus eliminating this test from further consideration. The most efficacious battery of tests for predicting success on the criterion consisted of the Read General Science Test, Form AM; the Mechanical Reasoning and the Verbal Reasoning Tests of the Differential Aptitude Tests; and the Mechanical Interest scale of the Kuder Preference Record ($R=0.7856$).

ROOSSINCK, ESTHER PAULINE.
Purposeful Reading of Science Materials by Scientists and Children.

Problem.—To investigate methods used by science professors when reading for two distinct purposes (to understand the main idea and to relate facts and ideas in sequence) and to compare the findings with comprehension, rate, and practices considered ideal in sixth-grade children as reported in an earlier study.

Procedures.—Forty-eight scientists (University of Illinois) read 10 science passages each, one-half reading to understand the main idea and the other half reading for relating facts and ideas in sequence. The scientists answered the same comprehension questions answered by the sixth-grade pupils. Records were kept on the original reading time, rereading, question answering time, and overt reading behaviors. Immediately, each scientist explained in a structured interview how he read the material and how he thought an ideal reader would have read it.

Findings.—The following differences in practices were significant at the 0.05 level. More of the scientists, reading for the

main idea than for sequence, reported reading faster than usual and skimming. The scientists reading for sequence reported rereading entire articles and turning back. More scientists reading for the main idea thought ideal readers would read faster than usual, begin at the beginning, and skim. More of the scientists reading for sequence thought ideal readers would turn back to the passages while answering questions.

When reading for the main idea, more scientists than sixth-grade pupils reported rereading parts of articles. More children looked over articles before reading, read every word, and vocalized overtly. The proportion of the pupils who regarded as ideal practices looking over the article first, reading every word, rereading entire articles, and vocalizing was greater than the proportion of scientists who reported doing so. When reading for sequence, more children than scientists reported reading every word, turning back, and vocalizing. More scientists reported pausing. More children regarded as ideal looking over articles before reading them, rereading entire articles, and vocalizing than scientists reported doing so.

SCHWARZWALDER, JOHN C. An Investigation of the Relative Effectiveness of Certain Specific Television Techniques on Learning.

Problem.—To consider techniques in the arrangement and presentation of televised material of fifth-grade science information to discover how best to use television as an instructional tool.

Procedures.—Three different techniques of television presentation and use were compared: (1) Visual continuity arranged for camera shots in a planned order versus an unplanned random order, (2) visuals reinforced with superimposed materials versus appearance without superimposed reinforcement, and (3) visuals manipulated by the teacher similar to regular classroom use versus television team and the teacher. These

three techniques were arranged in eight different treatment combinations for the teaching of fifth-grade science lessons on nine topics—plants, mammals, heat, machines, telegraph, wind, ground water, lenses, and longitude and latitude. Each topic was presented as a 25-minute lesson once a week to the 40 participating classes.

Tests were developed for each lesson, and validated on fifth grades not participating in the study. Analyses of variance and covariance were used to evaluate the results. The experiment was designed to test the effect of each technique by itself and in relation to the other two techniques.

Findings.—Twenty-two differences for the nine science areas were found to be statistically significant. In most instances the highest student achievement resulted from a combination of one technique using the television team production efforts and a second technique using only the teacher's effort. In general, the television production appeared to facilitate the effects of the teacher's efforts. Visual aids developed in cooperation with television production staffs contributed as much and in many instances more to student learning than did visuals prepared by the teacher alone.

TREXLER, CLARENCE R. A Study of the Relationship Between the Recorded and the Observed Conservation Behavior of Children in an Urban Environment.

Problem.—To determine the relationship between the children's testimony about their conservation behavior and their actual conservation behavior and the relationships between the consistency of the children's testimony and such personal factors as IQ, sex, academic achievement, and home background.

Procedures.—The study was carried out in a sixth-grade classroom in an elementary school in New Rochelle, N.Y. The procedures used in the study were to (1) develop an observational proce-

dures used to collect the observational data; (2) develop a conservation questionnaire used to collect the response data; (3) determine the relationship, by use of the product moment coefficient, between the observational and response data; and (4) determine, by use of the chi-square, the relationship between the consistency of children's testimony (responses to the questionnaire) and personal factors.

Findings.—The correlation between what the children testified and what they actually did was not strong enough to suggest that their testimony could be relied upon to ascertain their actual behavior. The children were more cognizant of their behavior concerning certain conservation situations, as suggested by the items on the questionnaire, than they were of other conservation situations. None of the items had a high enough consistency score to suggest that the children's testimony concerning particular items could be used to predict their actual behavior. None of the personal factors tested had a chi-square score which would suggest that the consistency of the children's responses to their actual behavior was affected by personal factors.

VICTOR, EDWARD. Why Are Our Elementary School Teachers Reluctant To Teach Science?

Problem.—To determine factors underlying the apparent reluctance of elementary school teachers to teach science.

Procedures.—A questionnaire was given to the 117 elementary school teachers in an Illinois city of 25,000. A total of 106 (90.6 percent) responded. Information gathered included sex of the teacher, teaching experience, background in science, time devoted to teaching science, and attitudes toward teaching science. Items calling for attitudes or opinions were usually asked three different ways to assure validity of response. Statistical techniques included *z*-test, chi-square, coefficients of correlation, and *t*-tests.

Findings.—The ratio of female teachers to male was 14 to 1. Most of the teachers were experienced, 80 percent having taught for 4 or more years and 65 percent for a decade or longer. Three-fourths of the teachers had taken less than 2 years of college science, with biology mentioned as the most common course. The typical teacher taught science about 30 minutes per day three times per week. Only 8 percent used demonstrations or experiments two or more times a week, while 42 percent used them once a month or less.

Chemistry was considered the most difficult to teach followed by physics, astronomy, geology, and biology. In general, the teachers felt that science teaching, even in the elementary school, should be the function of an expert. They reported their reluctance to teach science to be due to lack of familiarity with the subjects and science materials, and to embarrassment and dislike of repeatedly being in the position of not being able to answer pupils' questions.

ZAFFORONI, JOE. A Study of Pupil-Teacher Interaction in Planning Science Experiences.

Problem.—To analyze how a group of children and their teacher interacted as they planned for science experiences to

identify the critical factors contributing to interaction.

Procedures.—Teacher roles in pupil-teacher interaction were assessed from the literature. As a group of fifth- and sixth-grade pupils and their teacher planned their science experience, a skilled stenographer made a detailed record of the pupil-teacher interaction. All conversations were recorded, and notes were made of other reactions, such as laughter and facial expressions. The record was analyzed and four critical factors contributing to the interactions were identified.

Findings.—The four factors found to influence interaction most significantly during planning were (1) teacher's role, (2) pupil-teacher relationships, (3) use of materials, and (4) problem-solving situations. The teacher was identified in the roles of authority, laissez-faire, and counselor, the latter producing the highest quality of interaction among the group. Humor was noted to be an outgrowth of interaction. Printed materials and films exercised considerable influence in the amount and quality of the interaction. Records dealing with problem-solving situations indicated that interaction seemed to assume a higher level when unexpected problems occurred.

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Research Studies in Secondary School Science

APPROXIMATELY ONE-HALF of the total volume of science education research completed during the biennium of 1959-61 was concerned with the secondary school program. This section of the report contains abstracts of 55 of the studies completed, a critical analysis of these studies, an interpretation, and lists of studies completed between 1959 and 1963.

Analysis

The headings under which the studies have been grouped for this analysis are those fields of investigation listed on page 142. The assignment of a study to a particular field must always be an arbitrary decision, and other reviewers may have made different choices in certain instances. Although a study may apply to more than one field, it is discussed and listed only once.

Studies Related to Philosophy and Objectives.—Three studies were classified under the heading Philosophy and Objectives. All were analytical in nature and employed the questionnaire technique to some degree. *Aylesworth* investigated the attitudes of Michigan classroom teachers of science to ascertain their perception of problem solving as a worthy objective of science teaching and contrasted these attitudes with the actual practices of a selected group of teachers. He concluded that while teachers approve problem solving as a desirable goal of science instruction, not enough attention is being given by teachers to the direct teaching of problem solving.

The objectives of traditional high school physics were compared with those of the Physical Science Study Committee course by *Trowbridge*. He found 17 objectives unique to PSSC, 17 unique to traditional courses, and 38 joint objectives. The investigation showed that the teachers in both groups adhered strongly to the objectives identified as unique to their respective courses. The PSSC course emphasized the laboratory approach, an integrated film program, the contribution of physics as a pure science rather than applied science, the metric system, and the coverage of a relatively few topics in depth. Traditional course materials reflected objectives emphasizing applica-

tion, verification, and breadth of coverage in approximately 10 major areas. This study also showed that the degree of agreement and practice of the objectives of high school physics teaching by PSSC teachers and traditional teachers was strongly affected by the factors of school enrollment, years of physics teaching experience, and class size.

Lee attempted to determine the extent that it is possible or desirable, in a single high school physics course, to teach for the college preparation of pupils who will later become physics majors and for the general education of other pupils. He developed a list of specific content and behavioral objectives evaluated by physics professors, general physics students, science educators, and laymen. He found that the relative importance of the specific objectives appeared to be essentially the same for both groups. Skills of a behavioral nature were rated generally to be more important than most of the items of content.

Studies Related to Public Policy.—Four of the studies reported in this section were statewide surveys of the status of science teaching.

Science course offerings and enrollments, facilities and equipment, and qualifications of science teachers in Florida were surveyed by *Faber*. Nearly two-thirds of the pupils were taking one or more science courses. Biology was the most popular science subject and accounted for almost 50 percent of the pupils. Of the pupils enrolled in the last 4 years, 11 percent took chemistry and 5 percent physics. Facilities and equipment in most schools and the academic preparation of many of the science teachers were considered inadequate. The investigator concluded that many of the factors considered were so limited that they seriously threatened the academic opportunity of many of Florida's high school students.

In another state survey, *Cummins* found that the science preparation of teachers, facilities available, and programs in the small high schools in Oregon were inferior to those of the large high school. The combination classroom and laboratory was the most frequently reported type of facility being used. Teacher demonstration, pupil laboratory experiments, and science projects were more frequent in the large high school.

Gebhart, surveying the teaching of science in Montana, found that 95 percent of the high schools have smaller enrollments than that recommended by Conant for efficient operation. These small schools enrolled 55 percent of the State's pupils. Biology was the subject most frequently taught, and chemistry and physics were available in all but relatively few schools. In the small schools, and also in some of the larger schools, the science courses were often taught by teachers who were inadequately prepared to teach science.

Smith and others sent questionnaires to 1,322 science teachers in 614 approved 4-year public high school districts in Iowa, to ascertain curricular offerings and enrollments, qualifications and teaching loads of science teachers, and equipment and facilities available. The authors reported that those teachers with greater training in science displayed more interest in institutes and workshops; those needing improvement and preparation were not availing themselves of these opportunities. The median number of semester hours earned by Iowa science teachers was less than the minimum preparation recommended by the American Association for the Advancement of Science. Officials in approximately three-fourths of the school districts believed that their equipment and facilities were inadequate.

Hanson in his analysis of the science programs of Iowa secondary schools ranking high and low in science achievement recommended that administrators attempt to hire science teachers with recency of preparation and demonstrated professionalism. This recommendation was based on the findings that teachers of the high achievement group were frequently less experienced and had served for shorter periods at their schools, had participated in more National Science Foundation institutes, and had associated themselves more with professional organizations than the teachers in the low achievement groups. He also recommended that provision be made for laboratory work in all science classes.

Garrett in a study of the status and employment histories of 1,153 persons certified to teach in Louisiana from 1947 through 1956 found that about one-fifth had taught continuously since graduation and that nearly one-half the total group had not entered public school teaching. The reasons cited most frequently for not entering or for leaving the teaching profession were inadequate salaries, undesirable working conditions in the schools, and military or domestic obligations.

Staring tabulated data from records in the Louisiana State Department of Education in an investigation of the status of secondary school science teachers. Data were tabulated separately for white and Negro science teachers. Findings for both groups were approximately the same.

Edwards and *Wilson* from the University of California studied the specialization of attitudes as related to academic success at varying academic levels. The findings include: (1) Schools reward students with literary and verbal orientations more liberally than those with scientific and quantitative orientations, (2) the attitudes in a particular school vary according to the social conditions of the segment of the community from which it draws its clientele, (3) as pupils progress

through school, they assume increasingly the model aspiration of the particular school, and (4) children selected for advanced educational opportunity show orientations that associate with membership in the upper socioeconomic classes. The investigators concluded that pupils' responses correlate with other known variables, and might therefore be used to select students for advanced educational opportunities.

Edgerton, reporting for Richardson, Bellows, Henry & Co., concluded that summer science programs for high-ability secondary school students should be continued and enlarged because of potential stimulation of interest in and motivation toward science as a career. Scientist-educator observers visited 11 institutions enrolling 418 students. Interviews and questionnaires were used. Carefully controlled long-range followup studies were strongly recommended to aid in future program planning.

A second study by *Edgerton* was a followup of 1,550 high school seniors of 1942 and 1943 who competed in the Science Talent Search for the Westinghouse Science Scholarships. He found—

1. Science Talent Search examination scores were useful predictors of future college success in science.
2. Large high schools produced more scientists.
3. Teachers were the major influence for careers in science (except home influence was greatest for physicians).
4. Students lean toward science careers early, for many perhaps as early as the second or third grade.

Hurd reviewed biology teaching in American secondary schools for the period 1890–1960 for the American Institute of Biological Sciences. Each chapter included a summary of trends or developments, with comments that give perspective to the historical period of the research reported. An analysis was made of the factors limiting the effectiveness of national curriculum committees in bringing about desired changes in course content and teaching practices in biological education.

As part of the National Educational Association annual report of teacher supply and demand in public schools, *Maul* concluded that the supply of college graduates prepared to teach the sciences has been, and continues to be, far below the needs of the schools. Additionally, many college graduates prepared to teach the sciences are attracted to other occupations (the annual loss ranges from 30 to 45 percent); many school districts, through lack of available qualified teachers, fail to offer instruction in one or more of the science subjects; and, in addition, many districts assign teachers unprepared to teach these subjects.

MacCurdy, drawing on data from questions asked science- and engineering-oriented honors winners in the Science Talent Search for 1952 and 1953, describes the potential engineer as a socially oriented person who enjoys working with other people. He likes to work with his hands and feels that science is for man's use, and derives much satisfaction, encouragement, and help from his family, associates, and publications. The potential scientist was described as a solitary individualist who likes to search for essential values in complex things, and whose satisfactions come from his work and from his scientific associations.

MacCurdy also interviewed entrants at three State science fairs and concluded that occupational choices of the pupils are related to their first science interests which in turn occur most frequently during the elementary school years. This interest is associated with free play, pets, and scientific toys. Teachers and schools have become more influential in recent years and concentrate more on group, teacher-directed, and vicarious science activities.

Fisk sent questionnaires to national and regional winners and honorable mention award winners in the Science Achievements Awards Program of the National Science Teachers Association and their teacher-sponsors. He found that approximately 44 percent of the student projects were in biological science, 40 percent in physical science, 9 percent in earth science, and 5 percent in mathematics. Eighty percent of the projects were prepared outside of class and 50 percent received class credit. The parents of these students were well educated and the mothers were not "working mothers." The students plan to enter or are already enrolled in college.

In a comparison of science-talented and language-talented secondary school students, *Hosford* found differences in personality and ability to think critically.

Brown and *Obourn* sought to determine the background preparation of science and mathematics teachers in Maryland, New Jersey, and Virginia; to determine the teaching load and the teaching combinations of these teachers; and to develop a technique for securing data that might serve as a pattern to other States in making their own studies. A questionnaire was sent to 1,393 teachers, and college transcripts were studied. Nearly one-third of the teachers had the master's degree, with more than half of the advanced degrees obtained after 1950. About one-third of the teachers had average grades of A or B; fewer than 10 percent had an average of C or less. Nearly 60 percent of the science teachers had all or part of their training in liberal arts colleges, while about two in five attended a teachers college and/or a college of education in a university. More than 98

percent of the teachers reported an average of 47.4 semester-hours in science; less than 2 percent had taken no college science. The average class size was somewhat above the 1956 national average and increased with the size of the school. There was a better pupil-teacher ratio in the specialized sciences than in general science. More than 50 percent of the science teachers also taught nonscience subjects.

Studies Related to Curriculum.—*Hounshell* developed 23 laboratory experiences designed to lead students toward an understanding of basic chemical concepts, to involve students in problem-solving situations, to be adaptable to individual interests and abilities, and to be usable within limitations of time and equipment. These experiences were analyzed by a panel of high school chemistry teachers, college professors of chemistry, and science educators. The experiences were then tried out with a class of high school chemistry students. *Hounshell* concluded that laboratory experiences should present problems designed to involve students completely while allowing maximum freedom of thought and activity.

Harriman made an analysis of 12 recent high school chemistry textbooks and compared the topics found with the recommendations cited by the American Chemical Society in 1924 and 1957. He found that the textbooks contained topics more consistent with the recommendations of 1924 than 1957. The study question was the aid used most extensively. The emphasis was on facts with little emphasis on quantitative aspects of the subject. Many of the somewhat theoretical topics considered important by chemists were not included in current chemistry textbooks.

Values of extraclass science activities were investigated by *Potter*. Through a questionnaire, he secured information from 243 high schools in Colorado about science clubs and fairs. Fifteen schools reporting science clubs were matched with schools that had no clubs. The schools were visited and data were collected from students, teachers, and other school personnel. It was found that 56 percent of secondary pupils in Colorado were taking some work in science. Biology and general science had the largest enrollments. Only about 5 percent of the students contacted planned scientific careers and only 11 of 560 planned to be teachers. *Potter* concluded that teacher time and interest were essential requirements for successful science clubs and that, in general, science extraclass activities were associated with the more effective science teaching.

Lightner analyzed the status of advanced biology in large secondary schools of the United States. Surveying 135 courses, he found 85 percent of the schools offered advanced biology as a college preparatory or preprofessional course and three-fourths used a college-level, gen-

eral biology textbook. Research projects were undertaken in 88 percent of the courses. Eighty percent of the teachers had graduate degrees and 75 percent had taken college work within the past 5 years. The investigator concluded that advanced biology is being taught by well-prepared, professional teachers.

Principles for a 10th-grade biology course for all students were studied by *Rabb*. A list of principles was prepared and rated by 42 college biological science educators, 134 secondary school biology teachers, 77 recent alumni of 3 selected high schools, and 164 college students. On the basis of the ratings, it was concluded that a course of study in general biology should place major emphasis on the principles that come under the following topics: reproduction, protoplasm and cells, physiology and morphology, organization, energy and matter, ecology, and genetics.

Ozinonu identified six basic "observables" from Newtonian mechanics and then developed instructional units for ninth-grade science that were organized around these basic "observables." The units were so designed that the activities would help the students first develop a percept, then qualitative, quantitative, and abstract concepts of phenomena. The materials were tested with a group of high school freshmen for 55 class sessions. It was concluded that basic concepts, including those developed most recently, should be integrated into the high school curriculum. Their inclusion can assist high school freshmen to develop increased interest in and a positive attitude toward science and scientific thinking.

A determination of conservation principles and concepts for use in secondary schools was completed by *Visher*. He prepared a tentative list of generalizations selected from books, dissertations, journals, and other professional materials. A jury of 11 experts in conservation checked the accuracy of the statements, and 5 leaders in conservation education rated the final statements in terms of relative desirability for use in secondary schools. The final list included 477 generalizations in soils, forests, grasslands, minerals, wildlife, recreation and scenic resources, human resources, and general areas.

Batten's study indicated that earth science concepts were being taught in some of the secondary schools of North Carolina and that selected teachers felt that schools have adequate facilities to teach earth science. He also designed 18 basic laboratory experiences to emphasize the interrelationships of the functional and intellectual concepts of the earth with the basic biological and physical concepts. The experiences were tested in selected classes and were judged by college professors and teachers as to their difficulty, practicability, interest, and contribution to the development of understanding. The tryout revealed

that the material was of proper difficulty for the average student and also proved adequate for challenging the more able students.

Walters compared the achievement in high school biology as taught to 9th- and 10th-grade pupils and concluded that when a full range of abilities is represented in a class, biology could be taught in the 9th grade as effectively as in the 10th grade and that talented or lower ability 9th-grade students achieved as well as similar students in the 10th grade.

Thelen analyzed various sources for facts and concepts of chemistry which might be necessary for the understanding of the biological phenomena in certain biology curriculum materials. He assembled 511 facts and concepts which were evaluated by a panel of judges. Of these, 149 were designated *very important*, 259 *fairly important*, and 103 of *little or no value*.

Studies Related to Methods.—*Anderson* and others compared instruction using the Baxter chemistry films to nonfilm instruction. A total of 590 students participated. An extensive testing program was administered, and the data were treated by analysis of variance and covariance. The results indicated the pupils in nonfilm classes achieved more than those in the film classes. In 8 of the 17 direct comparisons, the results were significant and in favor of the nonfilm group, while in 3, the results were significant and in favor of the film groups. The pupils seemed to tire of the films. This may in part account for a decrease in the gain of the film groups during the last half of the year. Pupil reaction was not necessarily negative, for many pupils indicated that they had profited from various features of filmed instruction.

Black and others found that conventionally taught physics students achieved significantly more in subject matter than film-taught physics students, while there was no significant difference in chemistry achievement between pupils taught by films and taught traditionally. Compared to the pupils in the nonfilm groups, the attitudes of the film groups in both chemistry and physics were significantly unfavorable toward the respective subjects at the end of the experiment.

Grassell investigated two methods of teaching high school physics. One group of students viewed, as a part of their instruction, the entire series of the Harvey White Physics Films. The other group was taught by the traditional lecture-laboratory method. There were 255 pupils in the film group and 216 pupils in the traditionally instructed group. Instruction by films was as effective as the traditional lecture-demonstration method.

Anderson and *Montgomery* found that there was no difference in achievement between pupils taught by the Harvey White films and

pupils conventionally instructed in physics when intelligence quotients and pretest scores were held constant. However, since the experimental group had more significant variances from pretest to posttest than the control group, the investigators concluded that the film method produced somewhat superior results over the conventional method of teaching physics.

The Wisconsin Physics Film Evaluation Project study showed no significant differences in knowledge of subject matter between nonfilm groups and those using the Harvey White Physics Films. After 3 months, the nonfilm group retained more information covered during the first semester than the film group and significantly outperformed the film group in achievement at the close of the semester. Teacher reaction toward the films varied. Teachers with above-average preparation in physics tended to value the films less than teachers with less-than-average preparation. Pupil reaction varied; some thought the films were excellent for certain things, others expressed negative reactions.

In another study employing White Physics Films, *Nelson and Pella* attempted to determine the feasibility of using the films in improving the teaching of physics in the secondary schools of Turkey. The design of the study provided for a number of different comparisons in pupil achievement under various instructional situations. Pupil achievement was not significantly different between the groups taught by experienced teachers and those taught by inexperienced teachers when both used the films and associated materials. Achievement was significantly greater by the nonfilm group than the film group when both groups were taught by experienced teachers. Inexperienced teachers with little or no background in physics increased their understanding of the subject while teaching the film series. This appeared to be true also for the experienced teachers.

Kazem employed selected films in a 10th grade biology class in an effort to determine their effectiveness upon student understanding of the elements of scientific methods. Pupil understanding of scientific methods was increased through the use of the selected films. The informational-expository films (*The Scientific Method* and *Using the Scientific Method*) produced a significantly greater contribution to an understanding of the elements of scientific method than those of the historical-dramatic films (*Madame Curie* and *Pioneer of Flight*).

Strevel reported a study of the effectiveness of teaching high school physics by television. Physics was taught directly by television to 315 high school seniors in 15 school districts. Lessons were planned cooperatively, outlines were published, and television lessons were given 3 days a week for the entire school year. There were 31 control classes

in 24 high schools. Learning by television was more effective in homogeneous classes than in heterogeneous classes, and learning by television was equally as successful as in traditionally taught control classes. Team teaching was considered the primary condition necessary for effective television instruction.

A method of teaching chemistry that proceeded from teacher-directed situations to studies planned by the class and teacher and by small groups of pupils to studies planned by individuals was investigated by *Westmeyer*. Pupils achieved as well with this method as comparable pupils in other chemistry courses at the same level. *Westmeyer* concluded that when pupils are taught by a method that stresses the development of self-direction they can be expected to develop some degree of this trait.

Mark compared two different methods of teaching chemistry during laboratory periods. The control group performed experiments in standard laboratory manuals, while the experimental group devised methods of solving problems given to them before a discussion of that particular phase of work in the classroom. He found that both groups did equally well in the mastery of unrelated chemistry content and that the experimental group surpassed at the 3-percent level of confidence the control group in interpreting chemistry knowledge expressed in the form of paragraphs and diagrams.

Karle's experiment in teaching chemistry at Hunter College High School showed that the gifted 10th- and 11th-grade girls utilizing the open-ended experiments, developed by Manufacturing Chemists' Association, did equally well in the area of critical thinking as the girls who used the conventional laboratory exercises. This was likewise true for recall of information, application of principles, and interest in science.

An appraisal of the methods of teaching science in senior high schools of Montana was made by *Orlich*. He found the curriculum organization in order of frequency to be textbook, unit plan, and resource unit. The most frequently used methods were demonstrations, lectures, and individual reports. Laboratory periods were generally conducted in all sciences except general science. Forty-one percent of the schools did not use a laboratory period in their general science classes. General science was a reading course in almost half the schools.

Studies Related to Facilities and Equipment.—Several studies were reviewed that contained relevant information about facilities and equipment. Many of the studies were concerned with the total school programs and were therefore classified under the "Public Policy" heading. The only study reported under the "Facilities and Equip-

ment" heading is the survey completed by *Koelsche* and *Solberg*. On-the-spot inventories of the facilities and equipment were made in 855 schools. Data were collected on school enrollments, science enrollments, science offerings, and provisions for procuring equipment. An analysis of enrollments showed that 24.5 percent of the pupils were studying biology, 10.2 percent chemistry, and 5.6 percent physics. The investigators concluded that the facilities and equipment available for teaching science were inadequate in many of the public schools and that the greatest inadequacies were in the smaller schools.

Studies Related to Administration and Supervision.—Two investigators studied the responsibilities of supervisors. *Harwell* sent a questionnaire to teachers in systems employing a science supervisor to identify responsibilities which the teachers thought the supervisor should assume. Inasmuch as only 52 percent of the questionnaires were returned, his findings must be regarded as tentative. A study of the supervisor's conditions of employment, status, and professional responsibilities was completed by *Ploutz*. He found that supervisors at all levels spent most of their time assisting teachers in the classroom; providing materials, supplies, and information; developing the curriculum; organizing with department heads, principals, and superintendents; and providing inservice education.

Studies Related to Teacher Education.—Two studies were reviewed under this category. *Heisler* made an appraisal of the first Academic Year Institute for High School Teachers of Science and Mathematics at the University of Pennsylvania. He concluded that the participants had a favorable view of the institute and that improvement was demonstrated in knowledge of subject, understanding of social implications, and understanding of teaching and learning. He recommended that an intensive, comprehensive basic course in education should be made available to all candidates for the M.S. degree in education. *Yon* reported on the academic year institute at the Pennsylvania State University for 1957-58. Data were collected from questionnaires to teachers and administrators and from personal interviews. Personal gains listed by the teachers were advancement in professional status, acquisition of the background material necessary to do a better job of teaching, satisfaction with the teaching role, and increased motivation.

Studies Related to Evaluation and Research Design.—*Anderson* and others reported an evaluation of an introductory chemistry course on film by factorial design and covariance with method and career plans as the main variables and a similar evaluation with method and sex as the main variables. With method and career plans as the main variables, the film and nonfilm groups showed no significant differ-

ences in achievement with pretest and School and College Ability Test scores held constant. With the same scores held constant, the science career students achieved significantly more than the nonscience career students. In the latter evaluation, the nonfilm group achieved significantly more than the film group with pretest and SCAT scores held constant. Sex was not a significant variable.

Belt analyzed the effectiveness of two techniques of attitude measurement. One instrument was designed to measure accuracy of perception by use of factual items of the multiple-choice type, and the other, composed of the Likert-type, to measure favorableness of attitude. He concluded that the instrument composed of factual items presented less ambiguous stimuli than the fixed-response (Likert-type) items. He also compared the performance of a high-level ability group with that of a cross-section sample on Likert-type items. Twenty of the Likert-type statements were the same as used in the Purdue Opinion Panel Polls, and a comparison of the percentage responses obtained in *Belt's* study with those of the Purdue Opinion Panel indicated that relatively high ability pupils have more favorable attitudes toward science and scientists than do a representative cross section of high school pupils.

In a study to determine the relationship between the readability and comprehension of high school physics textbooks, *Marshall* concluded that the Flesch Reading Ease formula does not predict difficulty in the comprehension of high school physics textbooks.

Student behavioral changes and back-to-school consequences of a summer program in science and mathematics for talented secondary school students were investigated by *Cooley* and *Bassett*. Students improved in abilities measured by the Sequential Test of Educational Progress (STEP) Science test, but not by the STEP Mathematics test. Career plans seemed to shift toward increased interest in scientific research, and the distinction between science and technology became clearer. Pupils also showed increased realism in their image of science and scientists. A followup of the pupils in their respective schools did not indicate serious negative effects of the program, although some pupils felt that the regular classwork was less challenging. The investigators consider one of the important findings the observation that certain instruments are now becoming available which can detect changes in student behavior in areas other than factual subject matter.

Aldridge and *Anderson* investigated the relationship of the fundamental skills measured by the National Merit Scholarship Qualifying Test to natural sciences reading ability. They found that ability in natural science reading was accompanied most intensely by abilities

in word usage and social studies reading, and least by abilities in mathematics usage and English usage.

Silovsky and *Anderson* found that students who aspired to a National Merit Scholarship or who had been motivated to take the test tended to score themselves significantly higher on items of intellectual curiosity and persistence (self-evaluating items) than pupils who were not motivated to take the National Merit Scholarship Test. It was also found that pupils with high ratings on self-evaluating items tended to have high achievement scores in the humanistic and science areas on the test. These findings support the belief that intelligence, curiosity, and persistence are essential qualities for success in science.

One study was reviewed in which an effort was made to construct and validate a test of critical thinking. *Gulo* did this for ninth-grade students who had completed a course in general science. He also used ability to demonstrate existing relationships between critical thinking and assorted criteria to compare the effectiveness of two scoring procedures. Since the test correlated highest with the Read General Science Test, it may have measured science achievement more than any other quantified entity. The alternate scoring technique employed in the study disclosed relationships which might otherwise have remained obscure.

Interpretation

Most of the research completed from 1959 through 1961 at the secondary level has been completed to satisfy a requirement for an advanced degree. Of the 219 studies listed, only 65 had been published. A few may be published later, but the added number is not likely to be large.

Many of the criticisms directed toward research studies included in *Research in the Teaching of Science, 1957-59*, are still appropriate. The questionnaire technique continues to be used extensively. More than one-third of the studies abstracted used this technique, although several investigators supplemented it with on-the-spot observations or interviews. In some instances, it is questionable whether the researcher has used adequate control methods. In others, questions might be raised about the sampling techniques, both the size of the sample, and the degree to which it represents a given population.

The harshest criticism that has been made in the past has centered on the selection of the problems chosen for study. It is still true that many are peripheral to the basic issues of science education. Sometimes questions already resolved are further investigated without new

or different findings. The net effect is that much of the research "re-plows old ground" or deals with unimportant problems.

In contrast to these criticisms, several of the studies have contributed to the field of science education. Some have selected well-defined problems and designed the gathering and processing data carefully. In virtually all of the statistical studies, data were treated by analysis of variance or covariance. More specific contributions and criticisms are included in the paragraphs that follow.

Studies Related to Philosophy and Objectives.—The three studies relating to "Philosophy and Objectives" were concerned basically with the opinions of high school teachers, college professors, and laymen. Of these three studies, none was directly concerned with the rationale for the establishment of objectives within a specific philosophical framework or can be classified as status studies.

Studies Related to Public Policy.—The studies included under "Public Policy" for the most part were surveys of school enrollments, science offerings, academic preparation of teachers, and facilities and equipment. Data for the studies were gathered by questionnaire, interview, or a combination of the two. Three of the statewide surveys on the status of science teaching were completed as doctoral studies. Although these status studies satisfy a need for information about existing conditions, this type of investigation may not give doctoral students the best research experience. Status studies often make useful contributions by identifying problems which need further intensive research.

Studies Related to Curriculum.—Most of the investigators followed patterns used in earlier studies in which the researcher examines the published literature, extracts essential data, and then submits the materials to a panel of judges. In five of the nine studies, these panels reacted to the difficulty or suitability of materials used in the investigation. The concerns of the investigators appear to be directed toward the subject matter content (concepts and principles) of secondary school science courses to the exclusion of problems related to the processes of inquiry.

Studies Related to Methods.—In the area of methods, several investigators carried out comparative studies. More than half reported comparisons of achievement in the use or nonuse of films. No consistent patterns of superiority of either method are evident when total groups are compared. Some investigators made use of the further subgroupings based on teacher preparation, and others employed novel refinements in statistical techniques.

Studies Related to Administration and Supervision.—The studies in "Administration and Supervision" appeared to use traditional ap-

proaches. The studies were designed to identify the local supervisor's responsibilities, and in one survey the State supervisor was included. The latter study provides useful baseline data for future research in view of the increased number of State supervisors employed since the enactment of the National Defense Education Act.

Studies Related to Evaluation and Research Design.—Most of the investigations were concerned with behavioral changes rather than achievement. In two of the studies, the statistical procedures used extend the findings beyond data obtained by the use of common methods. Techniques for measuring attitudes were compared; tests of critical thinking were constructed and validated; and the back-to-school consequences of a summer program in science and mathematics were investigated.

The reports contain at least two important implications for future research. One investigator found that a commonly used reading formula did not predict comprehension difficulties of high school physics textbooks. Another study disclosed that test instruments are available which detect changes in student behavior in areas other than mastery of facts.

Selected Abstracts—1959-61

ALDRIDGE, BILLY G., and KENNETH E. ANDERSON. A Study of the Relationship of Fundamental Skills Measured by the National Merit Scholarship Qualifying Test to Natural Science Reading Ability.

Problem.—To find how four fundamental skills, as measured by the National Merit Scholarship Qualifying Test, affected natural sciences reading ability. The four fundamental skills were (1) English usage, (2) mathematics usage, (3) social studies reading, (4) word usage.

Procedures.—The sample consisted of 300 students who took the *National Merit Scholarship Qualifying Test* in 1958. Correlational and multiple regression analysis techniques were used to determine relationships between four fundamental skills and natural sciences reading ability. Standard scores, not raw scores, were used in the calculations. From the correlations of the four subtest scores with the natural sciences reading scores, it was possible to determine the relative contributions, in terms of variance, of the four independent variables to the dependent variable, natural sciences reading.

Findings.—The coefficients of correlation ranged from 0.52 to 0.66; the highest correlation in word usage, followed by social studies reading, English usage, and mathematics usage. The proportion of the variance mathematically accounted for indicated that ability in natural science reading had been accompanied by abilities in (1) English usage, (2) mathematics usage, (3) social studies reading, and (4) word usage, according to the relative weights of 1.14:1.00:1.47:1.59.

ANDERSON, KENNETH E., and FRED S. MONTGOMERY. An Evaluation of the Introductory Physics Course on Film.

Problem.—To test which method produced superior results in measured achievement during the period of one school year of instruction: the conventional method or the film method of instruction.

Procedures.—The study was done in two large high schools within the same school district in an eastern Kansas suburban county. One of the schools, with 9 physics classes containing 225 students and 2 teachers, served as the experimental group. The second school, with 7 physics classes having 176 students, served as the control group.

The Dunning Physics Test, Form AM, was given as a pretest at the beginning of the school year, 1958-59, Form BM of the same test as a posttest at the end of the school year, and the Terman-McNemar Test of Mental Ability, Form C, was used as an intelligence test during the middle of the school year, 1958-59. The technique of analysis of variance and covariance was used in this study.

Findings.—There was no difference in achievement between the two groups when intelligence quotients and pretest scores were held constant. Since the film method produced greater variability in achievement than did the conventional method, the film method was considered superior.

ANDERSON, KENNETH E., FRED S. MONTGOMERY, and SID F. MOORE. An Evaluation of the Introductory Chemistry Course on Film.

Problem.—To test which method produced superior results in measured achievement during the one school year of instruction: the conventional method or the film method of instruction.

Procedures.—Thirty-three chemistry classes with 590 students in five Wichita, Kans., high schools participated in the study. The 33 classes were composed of 7 film classes and 26 nonfilm classes. In the 26 nonfilm classes, the number was reduced to 8 by combining the classes of each teacher. The final composition of the groups used in the comparison were eight nonfilm groups and seven film groups.

The following tests were used: (1) the Anderson Chemistry Test, Form AM, as a pretest, midyear test, and posttest at the end of the school year; (2) the Laboratory Techniques and Apparatus Test for High School Chemistry as a posttest at the end of the school year; (3) the ACS-NSTA Cooperative Examination—High School Chemistry Form 1959 as a pretest and posttest. Part I was used as a pretest and part II was used as a posttest; and (4) the SCAT or School and College Ability Tests. Total score on this test was used in the calculations. Data were treated by analysis of variance and covariance.

Findings.—The data presented in this study would seem to indicate that the students in the nonfilm classes achieved more in high school chemistry than did the students in the film classes. This statement is supported by the fact that in 8 of the 17 direct comparisons, the differences in measured achievement were significant and in favor of the nonfilm group. Only 3 out of the 17 differences were significant and in favor of the film groups. In the ACS-NSTA Chemistry Examination, 5 of the 8 comparisons were significant and in favor of the nonfilm groups. The results were about equally divided in the Anderson Chemistry Test. It is possible that the tests measured different abilities in chemistry. Two of the five comparisons for the Lab-

oratory Techniques and Apparatus Test were significant and in favor of the nonfilm groups. Only one comparison was significant and in favor of the film groups.

ANDERSON, KENNETH E., FRED S. MONTGOMERY, and DALE P. SCANNELL. An Evaluation of the Introductory Chemistry Course on Film by Factorial Design and Covariance With Method and Career Plans as the Main Variables.

Problem.—To test which method produced superior results in measured achievement during one year of instruction: the conventional method or the film method of instruction. The population and rationale behind the present study are described in a previous study entitled *An Evaluation of the Introductory Chemistry Course on Film*.

Procedures.—The design of the study was a 2×2 factorial type. The factors were the two methods of instruction (film or nonfilm) and students' plans for college preparation toward a science or non-science career. Analysis of covariance was introduced in that the pretest (the Anderson Chemistry Test, Form AM) and School and College Ability Tests scores were held constant. The factorial design employed permitted stratification of the data and the testing of three null hypotheses as follows:

(1) Students taught by the film method did not differ in achievement in high school chemistry from the students taught by the nonfilm method with pretest and SCAT scores held constant.

(2) Students who planned to go to college for a science career did not differ in achievement in high school chemistry from students who planned to go to college for a nonscience career with pretest and SCAT scores held constant.

(3) The science career students did not differ in achievement in high school chemistry when taught by the film method and when taught by the nonfilm

method from the nonscience career students when taught by the same methods. The primary hypothesis was the first, and hypotheses (2) and (3) were introduced into the problem to make the first more meaningful than it would have been had they not been introduced.

There were 590 students distributed as follows:

<i>Film method:</i>	
Science career.....	65
Nonscience career.....	62
<i>Nonfilm method:</i>	
Science career.....	190
Nonscience career.....	373

Ten students were selected by means of random numbers from each of the four groups. Raw test scores were used in comparing the achievements of each of the groups.

Findings.—(1) The film and nonfilm groups achieved about the same with pretest and SCAT scores held constant. (2) The science career students achieved significantly more than the nonscience career students with pretest and SCAT scores held constant (F significant at 0.05 level).

ANDERSON, KENNETH E., FRED S. MONTGOMERY, and DALE P. SCANNELL. An Evaluation of the Introductory Chemistry Course on Film by Factorial Design and Covariance With Method and Sex as the Main Variables.

Problem.—To test which method produced superior results in measured achievement during 1 year of instruction: the conventional method or the film method of instruction.

Procedures.—The design of the study was a 2×2 factorial type. The factors were the two sexes and the two methods of instruction (film and nonfilm). Analysis of covariance was introduced in that the pretest and SCAT scores were held constant. The factorial design employed permitted stratification of the data and

the testing of three null hypotheses as follows.

(1) Students taught by the film method did not differ in achievement in high school chemistry from the students taught by the nonfilm method with pretest and SCAT scores held constant.

(2) Male students did not differ in achievement in high school chemistry from the female students with pretest and SCAT scores held constant.

(3) The sexes did not differ in achievement in high school chemistry when taught by the film method and when taught by the nonfilm method with pretest and SCAT scores held constant.

There were 590 students distributed as follows:

<i>Film method:</i>	
Male	79
Female	49
<i>Nonfilm method:</i>	
Male	289
Female	173

Ten students were selected by means of random numbers from each of the four groups.

Findings.—The nonfilm group achieved significantly more than the film group with pretest and SCAT scores held constant. Since the F values for sex and interaction were not significant, the conclusion was not biased by the factor of sex nor influenced by an interaction between sex and method.

AYLESWORTH, THOMAS G. Problem-Solving: A Comparison of the Expressed Attitudes With the Classroom Methodology of Science Teachers in Selected High Schools.

Problem.—The study was concerned with the attitudes of classroom science teachers in Michigan toward problem solving as a worthy objective of the teaching of science, with the methodology used in the direct teaching of this method as described by a select group of science teachers in Michigan, and with

the actual methodology used by this group.

Procedures.—Observations and tape recordings of 20 science classes in selected Michigan high schools of various sizes and in various science areas were made. Notes were taken and methodology was scrutinized and equated with a checklist of Obourn on the problem-solving objective. The teachers of these 20 classes were given a copy of a questionnaire following the observation. The questionnaire consisted of two parts: (1) information about the size of the school, and the teachers' backgrounds both in science courses and in science education courses, years of experience, and class schedule; (2) reactions to Obourn's 44 points, indicating whether they practiced problem solving in the classroom *always*, *almost always*, *occasionally*, *seldom*, or *never*. The questionnaires from these 20 teachers were compared with the observed and tape-recorded activities found in the classroom. The questionnaire was then sent to 194 teachers in Michigan, and the 142 returns were tabulated by size of school, number of science areas studied by the teachers, number of science education courses taken by the teachers, years of experience, and area of instruction.

Findings.—It was concluded that the original 20 questionnaires had been filled out realistically, inasmuch as the results tallied with the observation form that was used. Science teachers indicated they used the 44 checklist items: *always*, by 4 percent; *almost always*, by 32 percent; *occasionally*, by 47 percent; *seldom*, by 16 percent; and *never*, by 1 percent. The various items of background of the teacher caused the ultimate percentage frequency of the activity to change very little. Not enough attention was being given by these teachers to the direct teaching of problem solving. Although they stated that they approved of problem solving as an objective of science teaching, the teachers were not fully cognizant of the necessity for the direct teaching of problem solving.

BATTEN, JAMES WILLIAM. An Investigation and Analysis of Laboratory Experiences in Earth Science.

Problem.—To determine the extent to which earth science is emphasized and developed in typical high schools in North Carolina and to identify and design basic laboratory experiences which emphasize the interrelationships of the functional and intellectual concepts of the earth to basic biological and physical concepts and which provide opportunities for solving problems and developing scientific attitudes and interests.

Procedures.—The procedure followed was that of (1) reviewing the literature; (2) identifying earth science units and concepts in selected textbooks, laboratory manuals, and bulletins; (3) selecting the criteria and designing the experiences; (4) analyzing the experiences in selected classrooms; (5) seeking the opinions of college professors concerning the difficulty of material, nature and scope of the experiences, understanding of concepts, and equipment needed; and (6) distributing the experiences to teachers in a National Science Foundation Institute to obtain their opinions.

Findings.—Earth science was not included in the curriculum prior to 1900 except as individual courses in astronomy, meteorology, and geology. Emphasis was also directed to physical geography and physiography until the end of World War II. Then, earth science found its way into the curriculum and has accelerated slowly but continuously. Ten administrative units in North Carolina offer a course in earth science, eight units offer a modified course, integrating it in general science, and eight units are planning to incorporate a course in earth science in the near future.

All science textbooks used in North Carolina have specific units on earth science, except the chemistry texts and one physics text which have opportunities

for the development of earth science concepts. A tryout of the 18 selected experiences proved to be favorable. Some were completed in one class period; others required many periods. The material was of sufficient difficulty to attract the average student and proved adequate for challenging the more able students. College professors and teachers felt that the nature and scope of the experiences and opportunities for developing understandings seemed sufficient. Elaborate equipment was not required, and the *Word List for Study and References* would be advantageous to students.

BELT, SIDNEY L. Measuring Attitudes of Pupils Toward Science and Scientists.

Problem.—To analyze the effectiveness of two techniques of attitude measurement. One instrument, composed of certain types of factual items of the multiple-choice variety, was designed to measure accuracy of perception. The second instrument, designed to measure favorableness of attitude, consisted of statements followed by fixed answer choices—*agree—undecided—disagree* (Likert-type). The study also compared the performance of a relatively high-level ability group with that of a cross-sectional sample on Likert-type items.

Procedures.—A 20-minute questionnaire, consisting of items commonly hypothesized to be either precursors or outcomes of attitudes toward science and scientists, was first administered to 516 college-bound seniors in 12 New Jersey high schools. Two weeks later, the students were given the accuracy of perception test (factual items) and the favorableness of attitude test (Likert-type items). The items of the two tests were matched as to content.

Findings.—Although a significant positive correlation was observed between the attitude and perception tests, the correlation was too low to consider the two tests to be measures of the same func-

tion. The findings of this study do not support the implications drawn from two highly publicized studies which expressed concern for the Nation's future supply of scientists. The college-bound high school pupils of this study, a group that contains a relatively high percent of pupils with sufficient academic ability to pursue a scientific education, generally manifested favorable attitudes toward science and scientists.

Conclusions.—When beliefs are probed by factual items which measure accuracy of perception, less ambiguous stimuli are presented to the subject than when fixed-response (Likert-type) items are used to measure favorableness of attitude. The tests with factual items presented less ambiguous stimuli to the pupils than did the fixed-response items designed to measure favorableness of attitudes. Although the study concerned science and scientists, it seems reasonable to expect that accuracy-of-perception items should prove equally effective in probing underlying beliefs in other social and cultural fields.

BLACK, WM. A., W. JAMES POPHAM, J. M. SADNAVITCH. The Effectiveness of Filmed Science Courses in Public Secondary Schools.

Problem.—To evaluate the relative effectiveness of the filmed courses as contrasted with conventional instruction.

Procedures.—The sample was drawn from students enrolled in 12 secondary schools in Kansas offering both physics and chemistry. Six schools served as experimental for physics (taught by the film series) and control for chemistry (conventional instruction), and the other six schools served as experimental for chemistry (taught by the film series) and control for physics (conventional instruction). The original sample included 312 physics students, 155 taught by film; and 475 chemistry students, 234 taught by film. The students were pre- and post-tested. Analysis of covariance was used

in the statistical treatment of achievement data. Nonparametric statistical tests were used to analyze the interest schedule, attitude scale, and questionnaires.

Findings.—The major findings were (1) conventionally taught physics students performed significantly better than film taught physics students with no significant difference in achievement performance of the experimental and control chemistry groups; (2) there were no significant differences in interest shifts between the experimental and control groups, either for chemistry or for physics; (3) attitudes of the film taught students, both physics and chemistry, were significantly more unfavorable at the end of the experiment than those evidenced by their conventionally taught counterparts.

BROWN, KENNETH E., and ELLSWORTH S. OBOURN. Qualifications and Teaching Loads of Mathematics and Science Teachers in Maryland, New Jersey, and Virginia.

Problem.—To determine the background preparation of science and mathematics teachers in the selected States, the teaching load, and the teaching combinations of these teachers; and to develop a technique for securing data to serve as a pattern for other States.

Procedures.—Questionnaires were sent to 1,393 secondary school teachers of science and/or mathematics in 42 schools in Maryland, 58 in New Jersey, 92 in Virginia, and 26 in the city of Baltimore. College transcripts of the teachers were also studied. Data were compiled in statistical tables by State, size of schools, teacher's academic preparation, and teacher load.

Findings.—(1) About one-third of the teachers had an average in all subjects of A to B—; fewer than 10 percent had an average of C or less. (2) Nearly 60 percent of the science teachers in the study had all or part of their training

in liberal arts colleges and about two in five attended a teachers college and/or a college of education in a university.

(3) Sixty-four percent of science teachers held the baccalaureate degree and 33.3 percent the master's degree. Nearly half of the advanced degrees held by science teachers were obtained after 1950. (4) For all types of schools in the sample, 98.5 percent of the science teachers had an average of 47.4 semester-hours in science, the average number in science increasing with the size of the school. (5) Only 1.5 percent of the science teachers in the study had taken no college science. (6) Average class size was somewhat above the 1956 national averages, with the lowest in small schools and increasing progressively with the size of the school. (7) There was a better pupil-teacher ratio in the specialized sciences than in general science. (8) More than 50 percent of the science teachers taught other nonscience subjects.

COOLEY, WILLIAM W., and ROBERT D. BASSETT. Evaluation and Follow-up Study of a Summer Science and Mathematics Program for Talented Secondary School Students.

Problem.—To determine the student behavioral changes and back to school consequences of a summer program in science and mathematics for talented secondary school students.

Procedures.—The research operations consisted of two general phases: (1) Testing and interviewing during the 10-week summer session; and (2) followup questionnaires and interviews during the following school year to study the long-term summer's effects. The data collected from the testing program were compared with results from 200 students of the same age and geographic region who were subjects in the Harvard Scientific Careers Study.

Findings.—The major changes (of statistical significance) which were observed during the 10-week period involved the

student's image of science and scientists, and student plans for college and career. The trends in their image of science and scientists were, in general, toward increased realism. Also, the distinction between science and technology became clearer. Career plans tended to shift in the direction of increased interest in scientific research and included a new awareness that college teaching was a career in which research was possible. The students improved in abilities measured by the STEP science test, but not the STEP mathematics test.

The back-to-school followup did not reveal any serious negative effects of the program, although a few students reported a lack of challenge in their regular schoolwork. The most serious finding is the lack of followup interest in these students on the part of school and program personnel. Comparisons with peer groups were too complicated to describe here. An interest-temperament discriminant function was successfully validated.

Conclusions.—Standardized instruments are finally becoming available for science education research which can detect changes in student behavior in areas other than mastery of the facts about science. This summer program seems to be accomplishing what it set out to accomplish, without producing adverse co-effects.

CUMMINS, ERNIE LEE. Science Education in Public High Schools of Oregon.

Problem.—To survey the status of secondary school science teachers in the State of Oregon and to provide data for later comparison with a parallel nationwide survey being conducted by the U.S. Office of Education.

Procedures.—Existing conditions were surveyed in the secondary schools of Oregon during the 1958-59 school year. Fourteen areas were studied: (1) Personal data, (2) income, (3) other employment, (4) academic preparation, (5) workload, (6) facilities, (7) content and

organization of science courses, (8) methods of teaching, (9) laboratory and demonstrations, (10) textbooks, (11) aids to teaching, (12) problems in teaching, (13) professional participation, and (14) decision to become a science teacher. A questionnaire was sent to all secondary school science teachers in Oregon, and 485 teachers (75 percent) responded.

Findings.—Science preparation of teachers and facilities available in the small high schools were found to be inferior to those of the large high school. The science teachers in the large high schools had more adequate college preparation to teach science, more years of teaching experience, and fewer preparations than did science teachers in the small high schools. The science teachers in the large high schools received higher salaries, and were more satisfied with science teaching as a career than were those in the small high schools.

The combination classroom and laboratory was the most frequently reported type of facility used. A combination classroom and laboratory equipped for a single science was most commonly used in the large high schools, and a combination classroom and laboratory equipped for all sciences was most commonly used in the small high schools. The greatest shortage of equipment was in those items used for pupil experimentation. The science teachers in the large high schools made more frequent use of teacher demonstrations, pupil laboratory experiments, and science projects than did the science teachers in the small high schools. The area in which the greatest number of science teachers felt they needed further study were biochemistry, geology, nuclear physics, nuclear chemistry, organic chemistry, and astronomy.

EDGERTON, HAROLD A. Science Talent, Its Early Identification and Continuing Development.

Problem.—To determine: (1) how effective in terms of later realization the

selection methods used in the science talent searches have been; (2) the factors which aid highly selected boys and girls in achieving satisfying and effective careers in science; (3) what can be learned from the career and social patterns of people now established in scientific pursuits; and (4) what can be gleaned from observations of scientists as to the career changes they would make if they "had it to do all over again."

Procedures.—A six-item questionnaire was mailed in 1957 to the participants of the first two annual science talent searches (1942 and 1943). From the 1,550 who returned this brief questionnaire, 150 were selected to answer a more detailed one covering their history since high school and to be interviewed about their career and development. Interviews were conducted with 136 of the 150.

Findings.—High school seniors who achieved the highest test scores on the science talent search examination administered annually were most likely to attain the higher degrees in college. Students who stayed in science as a career came on the average from larger high schools than those who went into nonscience fields. Teachers were the major influence for careers in science (except home influence was greatest for physicians). Students lean toward science careers early, for many perhaps as early as the second or third grade. No science talent search winner among those 136 interviewed had changed his early choice as a profession, although some changed areas of science.

EDWARDS, T. BENTLEY, and ALAN B. WILSON. The Specialization of Attitudes as Related to Academic Success at Varying Academic Levels.

Problem.—To determine the specialization of attitudes as related to academic success at varying academic levels.

Procedures.—Data on a number of variables were collected from many students to test hypotheses regarding associations among these variables. The variables included success in schoolwork, socioeconomic status, IQ, sex, age, educational and vocational aspirations, leisure-time activities, school subjects preferred, and scores on the Edwards-Wilson Inventory of Academic Attitudes. The pupils were chosen to provide a wide range within each of these variables.

Information was obtained by means of questionnaires, interviews, and school records. The sample was divided into two or more groups for a given variable. These groups were then subdivided and the process continued until the numbers in a particular cell disappeared. Percentages in each of the various cells were calculated and compared. A Fortran program was written for testing the significance of the differences shown, using several variables simultaneously.

The sample included 4,500 high school pupils from cities in the San Francisco Bay area; 900 secondary school pupils from London, England; and 1,200 elementary pupils in one of the bay area cities.

Findings.—(1) The schools reward those with literary and verbal orientations more liberally than those with scientific and quantitative orientations. (2) The climate of attitudes in a particular school varies according to the social conditions of the segment of the community from which it draws its clientele. (3) As they progress through school, children assume, increasingly, the model aspiration of the particular school. (4) Children selected for advanced educational opportunity show orientations that associate with membership in the upper socioeconomic classes. Students respond to measures of attitudes in a reasonably consistent fashion. Their responses correlate with other known variables and might therefore be used, consciously, first to select students for advanced educational opportunities and, second, to modify curricular disposition.

FABER, SHEPARD. A Survey of Selected Provisions for High School Science Instruction in Florida.

Problem.—To survey (1) science course offerings and enrollments, (2) facilities and equipment used in teaching science, and (3) the academic qualifications of the science teachers.

Procedures.—A random sampling of 25 percent of the high schools of Florida was made during the academic year 1958-59. A survey team collected information from the 81 schools in the study about science offerings, enrollments, facilities, and equipment on itemized instruments. Data on academic backgrounds of teachers were obtained from college transcripts. A teacher questionnaire was constructed to ascertain the teachers' opinions about the adequacy of their academic backgrounds, and of equipment and supplies available for teaching science.

Findings.—Offerings in Florida schools exceeded the national average slightly. The number of different science courses offered was found to be related to school size; larger enrollments enjoyed more extensive offerings. Access to science courses was denied, to the greatest extent, to students enrolled in schools having fewer than 500 pupils. The average science class contained 27 students; the larger schools had the largest classes.

Nearly two-thirds of students were taking one or more science courses. Biology, required by State law, accounted for almost 50 percent of these; chemistry, 11 percent; and physics, 5 percent.

On the basis of science teacher judgment, the quality and quantity of equipment and facilities was rated in descending order: chemistry, general science, biology, and physics. On the basis of an equipment index, items most available for science teaching were rated in descending order: chemistry, biology, physics, and general science.

Of 315 teachers teaching science, 8.6 percent were not fully certified. Violations, in descending order, were teachers

of physics, chemistry, biology, and general science. The average science teacher had deficiencies in academic preparation in both subject taught and related subjects. Almost one-half of the science teachers indicated lack of equipment and supplies as their greatest source of difficulty. Nearly three-fourths of science teachers wanted to take courses in science content to increase their competency.

FACULTY PROJECT COMMITTEE. The Wisconsin Physics Film Evaluation Project.

Problem.—To evaluate the effectiveness of the Harvey White Physics Films as they might be used in ongoing, representative, high school physics study situations in typical classroom situations and locally supervised correspondence situations.

Procedures.—Eighty-three Wisconsin high schools which agreed to participate in the project were placed in a 3×2 statistical grid established by three levels of teacher preparation and two levels of student intelligence. From this grid, 30 experimental and 30 control schools were selected at random. During the fall semester of 1957, each school (X group) was scheduled to view one of the half-hour films per day and to use the lesson outlines provided. Control classes (C group) were taught in the usual manner without the films. At the end of the 90-day experiment period a third group of schools (CC group) was invited to join the experiment. This group was used to measure any possible *Hawthorn effect*. Numerous materials, such as study guides and tests, were developed for the study.

Findings.—(1) No significant difference was found between the X and C groups in physics presented in films and textbooks; the X group achieving significantly higher scores than the C group on tests of information presented only in the films. (2) The C group retained more first-semester information than the X group after 3 months. The groups had

been equated on the basis of end of the semester scores. (3) The C group outperformed the X and CC groups at the end of the semester with significant differences at the 0.05 level when tested by analysis of covariance. (4) Film-using teachers agreed that the film used too much of the classtime. (5) Teachers with above-average preparation in physics tended to reject the films as instructional material. Those with less-than-average preparation tended to accept the films as a means of improving instruction. (6) Half of the teachers in the experiment said they would use the films under conditions less rigid than those imposed by the experiment. (7) Teachers felt that a film a day did not provide enough variety in the physics course. (8) Students felt that Dr. White did an excellent job in explaining the development of formulas. (9) Students believed that in the films excellent use was made of charts, diagrams, equipment, and experiments in developing new concepts. (10) Some students thought the pace in the films was too fast; the laboratory films were too long, drawn out, and boring; there was no chance to ask questions; the mathematics was too involved; and there was not enough time to practice or to do actual laboratory work.

FISK, FRANKLIN G. An Evaluation of a National Awards Program in Secondary School Science.

Problem.—To collect information on the Science Achievement Awards for Students (SAAS) and on the students and teachers involved in past programs.

Procedures.—The information was obtained from a nationwide study of national and regional winners and honorable mention award winners in the first 6 years of the program's existence. The study also solicited information from the teachers who were sponsors of these award-winning students. An attempt was made to contact every regional and national winner and their teacher-

sponsors, and a 10-percent stratified random sample of the honorable mention students and their teacher-sponsors for the first 6 years of the program was selected by year, grade, and geographical area. An initial mailing to the schools of 408 lists of names of teachers and students to obtain correct addresses resulted in 400 returns in 3 months.

Findings.—Approximately 44 percent of the projects were in biological science, 40 percent in physical science, 9 percent in earth science, and 5 percent in mathematics. The remaining projects were not covered by the above categories. Eighty percent of the science projects were prepared outside of class, and 50 percent received class credit. The median time spent on the project entered was from 4 to 6 months; the median cost of the project was from \$6 to \$9. The parents were very well educated, and the mothers were not "working mothers." Fifty-six percent of the fathers and 52 percent of the mothers had been educated beyond the level represented by high school graduation. Approximately 12 percent of the fathers had earned the doctorate degree. The fathers held positions consistent with their level of educational preparation, 35 percent in professional and 15 percent in managerial occupations as classified by the Dictionary of Occupational Titles. One-half of the fathers classified in a professional occupation were engaged in scientific occupations.

The students planned to enter, or were already enrolled in college. From 70 to 80 percent of the winners and honorable mention students were planning to, or were already majoring in science or science-related fields of study in college. The students took a large number of science and mathematics courses and were very active in nonathletic types of extracurricular activities. Judging from the number of science and nonscience awards received in school, the regional winners and honorable mention group were outstanding students.

GARRETT, JOHN L., Jr. A Study of the Status and the Employment Histories of White College Graduates Certified as Science Teachers in Louisiana (1947-56).

Problem.—To investigate the status and employment histories of persons certified to teach science in Louisiana from 1947 through 1956.

Procedures.—Data were gathered from records in the State department of education and the State teachers retirement office and by a questionnaire sent to those certified persons who had not entered teaching.

Findings.—During the 10-year period covered by the study, 1,153 persons had been certified to teach science in Louisiana. The following was revealed: (1) A majority were graduates of State-supported colleges in Louisiana. (2) Only a relatively small number had earned graduate degrees. (3) There were approximately twice as many men as women prepared for science teaching during this period. (4) A majority were certified to teach in two or more science areas. (5) Mathematics was the most likely nonscience area of specialization. (6) In professional education, a median of 22 semester-hours had been earned by the group.

On the basis of their work records, the 1,153 persons fell into 5 employment categories. About one-fifth had taught continuously since graduation. Approximately one-tenth had taught intermittently but were teaching in 1956-57. Almost one-fifth entered teaching but had left. A few were in school-related but nonteaching jobs. Finally, and this appears to be significantly related to the maintenance of an adequate supply of science teachers, nearly half of the total group never entered public school teaching. Men were more inclined to remain in teaching than women. It was found that a large majority of the nonteaching group were

housewives, industrial employees, or in military service. Reasons cited most frequently for not entering or for leaving the teaching profession were inadequate salaries, undesirable working conditions in the schools, and military or domestic obligations. Over half of those responding to the questionnaires said that they would like to teach if conditions were more favorable.

GEBHART, JAMES WARREN. The Teaching of Science in the Secondary Schools of Montana.

Problem.—To survey the science education program in Montana public secondary schools, to determine the relationship between school size and course offerings and teacher assignments, and to evaluate the preparation secondary school science teachers of Montana.

Procedures.—Data were secured from annual secondary school reports to the State department and from college transcripts of 205 Montana-trained secondary science teachers. Information on conditions specific to Montana was obtained. Data were tabulated for nine school-size categories according to science curricula and included high school science enrollments, courses taken, and credit-hours in science earned by general science, biology, chemistry, physics, and geology teachers. Data were compared with findings of previous national surveys and two earlier investigations of a similar nature.

Findings.—Many science courses are taught by persons certified for nonscience areas. In fact, many are taught by persons having less than 1 year of basic course work in that field. Even in larger schools, teachers are inadequately prepared. They are best prepared in biology and most poorly prepared in physics. With rare exceptions, teachers lack background in geology. Most postdegree work is done for graduate credit. Summer offerings in sciences are meager. Graduate credit is not given for basic courses.

Hence, teachers tend to take additional work in an area in which they have a considerable number of credits rather than to broaden their background.

GRASSELL, EDWARD MILTON. An Evaluation of Educational Films in the Teaching of High School Physics in Oregon.

Problem.—The major purpose was to determine the effectiveness of teaching high school physics by two different methods of instruction during one entire school year.

Procedures.—Part of the instruction for one group of students included the entire series of White physics films; the other group was taught by the more traditional lecture-laboratory method. The criteria used in selecting the film-group schools were their geographical locations and their willingness and ability to pay the \$350 film rental fee. Each item was a limiting factor. The subjects included 255 pupils in the film group and 216 pupils in the nonfilm group. All of these students were juniors and seniors. In the film group, 13 percent were girls and 87 percent were boys; the nonfilm group contained 8 percent girls and 92 percent boys. Questionnaires were given to both the students and teachers in both groups during the first week of school and 2 weeks before the end of the school term. Pretests were given during the first week of the school to help equate the film and nonfilm groups, and to provide a basis for determining achievement. Three teacher-made unit tests, given during the year, included units in mechanics, heat, and electricity. At the end of the year two of the standardized tests used during the pretesting period were repeated to help determine the difference of achievement between the two groups.

Findings.—Secondary school physics courses taught primarily with the White physics films are as effective as courses taught in the more traditional lecture-demonstration manner.

GULO, ELIOT VAUGHN. The Construction and Validation of a Test of Critical Thinking for Freshmen High School Students Who Have Completed a Course in General Science.

Problem.—To construct and validate a test of critical thinking for high school freshmen who had a course in general science in their freshman year. In addition, an attempt was made to gauge the effectiveness of several scoring procedures in terms of their ability to demonstrate existing relationships between the Critical Thinking Test and assorted criteria.

Procedures.—The test was constructed in 12 parts, each called a series and composed of four items. The first item, with only one correct answer, was followed by three items designed to measure processes operative during solution of the first item and each having as many as four possible correct answers. The test was administered to sophomores at New Bedford High School, Massachusetts, who had completed a course in general science during their freshman year. Tests were scored utilizing two scoring procedures. The first yielded a Composite Critical Thinking Test score which rewarded the pupils for the degree of knowledge they demonstrated concerning the stipulated tasks of each series. The second penalized the composite score by subtracting for errors and inconsistencies which indicated a lack of knowledge of the dynamics involved in the series. This yielded an Adjusted Critical Thinking Test score. Criteria were established and a correlational matrix was formed utilizing the correlations between Adjusted Critical Thinking Test scores and the criteria. This was followed by a factor analysis to determine the validity of the Test of Critical Thinking.

Findings.—A split-half technique was used to correlate the odd and even series. This produced a value of 0.59 for the re-

liability of the unit length test. The effectiveness of both scoring procedures was determined by comparing the Composite Critical Thinking Test-Criteria Correlations with the Adjusted Critical Thinking Test-Criteria Correlations. In every instance, the second scoring procedure resulted in an increase in the correlation. The Read General Science Test correlated 0.30 with the Composite scores and 0.45 with the Adjusted scores. The correlation of Otis IQ was similarly raised from 0.23 with the Composite scores to 0.30 with the Adjusted scores. The Critical Thinking Test may have measured science achievement more than any other quantified entity.

HANSON, ROBERT W. Isolating the Factors That Contribute to the Effectiveness of High School Science Programs.

Problem.—To isolate and describe the differences that existed between the science programs of two groups of schools known to differ markedly in the amount of growth in science achievement demonstrated by students during the first 3 years of high school.

Procedures.—The Iowa high schools that administered the Iowa Tests of Educational Development in 1956 and 1959 were ranked according to the average change in the mean of student scores on Test 2 (General Background in the Natural Sciences) and Test 6 (Ability to Interpret Reading Materials in the Natural Sciences). Twenty schools were selected from the upper extreme of this distribution at random and matched with 20 from the lower extreme on the basis of ninth-grade ITED composite score to control mean level of ability and ninth-grade mean of Test 2 and 6 to control initial level of achievement. All 40 schools were visited in the spring of 1960. Data were gathered through observation, interview, and questionnaire. Numerical scores were computed for the factors compared for each school and were used to conduct significance tests of the differences

between achievement group means using the *t*-test for related measures. Analysis of variance was used to test the significance of the interaction between school enrollment-size category and achievement.

Findings.—Students in schools showing the greatest growth in science achievement (1) were more likely to have taken physics rather than chemistry in the 11th grade but had not necessarily taken more science than students in schools showing the least growth in science achievement, (2) more often expressed an intention to go on to college and planned to major in a science area in college, and (3) considered their teachers to be more effective than did students of the low achievement group.

Teachers of the high achievement group frequently had less experience and had served for shorter periods at the schools than teachers in the low achievement group. More of them had participated in National Science Foundation institutes and were members of professional organizations for science teachers. There were no significant differences between the teachers of the two groups in their college preparation. Student demonstrations took the place of individual laboratory work in chemistry classes to a larger extent in the low achievement group; dependence on motion pictures and filmstrips was less evident in the schools of the high achievement group; more formal class conduct and better teacher control of the classroom situation was apparent in the schools of the high achievement group; more frequent use of longer tests and less frequent use of short tests was apparent in the schools of the high achievement group especially in chemistry; and mathematics was used more extensively in the teaching of physics in the high group.

More of the low group schools were teaching nonlaboratory science courses and were using ordinary classrooms for science instruction. Chemistry and

physics were more frequently offered on a yearly basis than on an alternate year basis in the high achievement group.

HARRIMAN, VERNON JOSEPH. The Inclusion of Modern Chemistry in Current Secondary School Chemistry Textbooks.

Problem.—To determine the extent to which current secondary school chemistry textbooks contain and emphasize recommended recent topics in chemistry.

Procedures.—An analysis of 12 selected recent chemistry textbooks by comparative and tabulative techniques was made. Topics were compared with the recommendations from the American Chemical Society found in the *Journal of Chemical Education* in 1924 and 1957.

Findings.—(1) The current chemistry texts contain topics more nearly similar to those in the 1924 standard course than those in the standard course developed in 1957. (2) Current chemistry texts introduce material on elements quite early. The first elements to be considered in all of the texts studied were oxygen and hydrogen. (3) The most extensively treated topic in the texts was organic chemistry. Other topics which received substantial coverage were nitrogen, water, metals, sulfur, acids and bases, and halogens. (4) The chemistry textbooks are highly illustrated, pictures predominating. The 12 texts combined contain 2,955 pictures. Individual texts may average one picture per page. (5) Outside references were listed in only about half of the textbooks, and in those the number of references listed was often small. (6) The most extensively used study aid was the study question. The 12 texts combined contained a total of 17,592 study questions, 15,350 factual in nature and 2,242 quantitative.

HARWELL, JOHN EARL. The Responsibilities of the Science Supervisor as Indicated by Science Teachers.

Problem.—To attempt to determine the responsibilities of science supervisors as indicated by science teachers.

Procedures.—The science teachers who took part in the study were members of the National Science Teachers Association and were employed in school systems that had a science supervisor during 1960-61. The questionnaire had two parts. Part I had 12 sections with the following titles: Classroom visitation, inservice development of teachers, methods and techniques, materials and resources, equipment and supplies, research, philosophy, professional growth, administration, science personnel, school plant, and public relations. Each participant was asked to indicate the degree his science supervisor performed the responsibilities listed in each section, the item in each section thought to be most important, and whether he considered each item the responsibility of science supervisors. Part II of the questionnaire consisted of six items designed to obtain from the respondents information about their teaching experience, professional preparation, and subject or subjects taught.

The 261 replies used represented 52.2 percent return. Science teachers in 30 States and the District of Columbia cooperated in the study. Science teachers in 106 school systems of 30,000 population or more were asked to take part in the study. Eighty-one cities were represented in the study.

Findings.—Responsibilities of science supervisors were identified from the replies. There were 81 responsibilities in the questionnaire which 50 percent or more of the respondents indicated science supervisors should assume.

HEISLER, RICHARD S. An Appraisal of the First Academic Year Institute for High School Teachers of Science and Mathematics at the University of Pennsylvania.

Problem.—The hypotheses tested were that after participating in an academic

year institute measurable improvement would take place in knowledge of subject, understanding of science in the context of society, knowledge and understanding of teaching and learning, and classroom performance.

Procedures.—The sample consisted of 51 participants in the academic year institute, 32 of whom were candidates for the master of science in education. The Graduate Record Examination Advanced Tests in biology, chemistry, mathematics, and physics were administered to each participant in his principal field of study in September and the following May. The Kolmogorov-Smirnov Test was employed to evaluate differences between each set of scores and the scores of a standard reference group. Changes in the means of the two sets of scores were appraised by the *t*-test. A subjective examination based on an excerpt from *Science* was administered at the same times. Diagnostic and final forms of the Comprehensive Examination in Education were administered respectively in January and May, at the regular times. Changes in mean score for the subjective examination relating to science and society and on the comprehensive examination were evaluated by the *t*-test. A rating scale and checklists were sent to secondary school supervisors for each participant prior to and following the year of study. The Wilcoxon signed rank test was applied to data derived from the rating scale, and the sign test applied to the checklists. Finally, a questionnaire designed to elicit opinions of the participants and to gather further information was submitted in May. Responses which related to aspects of the institute and related information were counted and analyzed.

Findings.—Mean scores on the Graduate Record Examination were lower than those of the corresponding reference groups for all of the institute disciplines, initially. The differences were statistically significant in physics and mathematics. Retest scores showed superior

achievement of the institute groups in biology and chemistry, and superiority of the reference groups in mathematics and physics. The differences were statistically significant for biology and physics. Improvement in the retest was statistically significant for biology and physics. Improvement in the retest scores was significant for all disciplines except physics. Improvement in the retest scores for the essay test was statistically significant for each of the institute disciplines. Mean scores on the diagnostic form of the Comprehensive Examination in Education fell below the norms for 3 of the 5 subsections and for the total. On the final form mean scores of the same examinees exceeded the norms by at least half a standard deviation for each subsection and by approximately one standard deviation for the total. Improvement of the final scores over scores on the diagnostic form showed statistical significance for each of the five phases of the examination and for the examination as a whole. Improvement in supervisors' opinions of teaching performance was evident in 14 of the 17 items. These were significant in only four cases. Data regarding changes in patterns of classroom activities and sources of information used by students were inconclusive.

HOSFORD, PRENTISS M. Characteristics of Science-Talented and Language-Talented Secondary School Students.

Problem.—To identify characteristics or attributes exclusive of intelligence, socioeconomic background and education, related to science talent.

Procedures.—In the study, 102 science-talented secondary school students and 108 language-talented students were used. Data were obtained from the Heston Personal Adjustment Inventory, Structured-Objective Rorschach Test, Facts About Science Test, and Kuder Preference Record. A personal data sheet developed by the investigator and

school records were also used. Statistical analyses to determine significant differences (0.05 level or higher) between science- and language-talented boys and girls consisted of intergroup comparisons of the means for variables involving continuous data and of percentages for variables involving discrete data.

Findings.—(1) No significant differences were found between language-talented and science-talented students in age, size of sibling group, sibling rank, and education of parents. (2) Science-talented boys and girls scored significantly higher on analytic thinking. (3) Science-talented boys and girls have higher quantitative aptitudes, while verbal aptitudes are comparable. (4) Significant differences in school marks existed in that higher English grades were obtained by language-talented boys and higher science grades by science-talented girls. (5) Certain perceptions, concepts, interests, and characteristics of the science-talented girls more nearly approached those of the boys than those of their language-talented peers, supporting the suggestion that many characteristics are common to scientists exclusive of sex differences.

HOUNSHELL, PAUL BARRYMAN.
The Design and Analysis of Laboratory Experiences in High School Chemistry.

Problem.—To identify basic concepts of chemistry and to design laboratory experiences which develop functional and intellectual concepts and utilize a problem-solving approach.

Procedures.—The literature relating to the topic was reviewed, basic chemical concepts were identified, and high school chemistry laboratory experiences were designed and analyzed. Twenty-three laboratory experiences were designed which, by their organization, would lead to an understanding of basic chemical concepts, cause students to become involved in problem-solving situations, be

adaptable to individual interests and abilities, and could be adapted to time and equipment limitations. Each of the experiences was analyzed by a panel of high school chemistry teachers and college professors of chemistry and science education to determine their apparent effectiveness. A class of high school chemistry students also performed the experiences under the guidance of the writer.

Findings.—On the basis of opinions of the participants in the study, the experiences were considered effective in terms of the selected criteria. The findings further indicate that high school chemistry laboratory programs should be organized around problems which provide opportunities for students to become totally involved in their solution and that experiences should be designed to allow students maximum freedom of thought and activities. Students should be given ample time and facilities to determine experimentally factors relating to the solution of problems, to obtain and record significant data, and to analyze these data as they relate to the problem.

HURD, PAUL DEHART. Biological Education in American Secondary Schools, 1890-1960.

Problem.—To review the development of biology teaching in the American secondary schools for the period 1890-1960.

Procedures.—The study was based upon two kinds of data: (1) published reports of curriculum committees and (2) investigations of curriculum and learning problems. Committee reports were used to trace the history of modern biology teaching because they typically describe the rationale for proposed changes. The following criteria were used for the selection of the committee reports: (1) The reporting committee was national or regional in scope or was an official committee representing a biological society, (2) their primary interest was curriculum improvement, and (3) the mem-

bers were qualified through research or teaching experience.

The first part of the study was devoted to committee reports, presented in chronological sequence and summarized by decade. The second part brought together research on curriculum and the learning of biology. The research reviewed related to objectives, criteria for selecting course content, textbooks, learning, and instructional resources for teaching biology. The investigator made an interpretive summary of each topic.

Findings.—The first decade of the study (1890–1900) was characterized by an emphasis upon “mental discipline” and an intensive study of plant and animal structure. During the period from 1900 to 1920, general biology was introduced, and enrollments in the new course increased rapidly. The twenties were a period of curriculum refinement in general biology with attention given to elements of scientific method. Between 1930 and 1950, general education and life adjustment were the most pronounced developments. The investigator characterized the last 10 years as a period of crisis and reappraisal.

In part 2, the analysis of research on objectives and content of biology courses reveals increasing emphasis on the processes of science. A logical organization of courses does not necessarily result in the most effective learning. Although laboratory work does not appear to increase factual knowledge, it is essential for developing skills in problem solving.

KARLE, IRMGARD F. A Comparison of Open-Ended Chemistry Experiments With the Conventional Laboratory Exercises in Teaching Selected High School Chemistry Classes.

Problem.—To compare the relative effectiveness of open-ended experiments with the conventional laboratory exercises in teaching selected high school chemistry

classes in critical thinking, interest in science, and achievement.

Procedures.—Experimental and control groups were set up with two 10th-year classes and two 11th-year classes of Hunter College High School. Each 10th- and 11th-year experimental section had 24 pupils and each control section had 21 pupils. The investigator taught all four recitation and laboratory sections. The classwork was identical in the four sections; the laboratory work was, however, quite different. The experimental sections used the open-ended experiments sponsored by the Manufacturing Chemists' Association for their total laboratory experience. The control group performed exercises from the manual *Laboratory Experiments in Chemistry* by Brownlee, Fuller, and Whitsit. The students in the control groups recorded their observations in the laboratory manuals and answered the questions in each exercise. In the experimental groups the students handed in a written report which incorporated a statement of the problem undertaken, observations made, and conclusions drawn. For measuring critical thinking, the STEP Science Test, Level 2, Form 2A, was used as a pretest, and Form 2B as a posttest. Data were analyzed by means of covariance. The Kuder Vocational Preference Record, Form Ch, was used as a measure of student interest in science. The instrument used for evaluating achievement was the ACS-NSTA Cooperative Examination in High School Chemistry, Form 1959. This test was administered in May 1959, and the data thus obtained were used as the Y-variable in the analysis of covariance. The X-variable in this instance was the score achieved on the Lorge-Thorndike Intelligence Test.

Findings.—Results of the analyses indicated there was no significant difference between the two methods of laboratory work in developing critical thinking, interest in science, recall of information, application of principles, and the quantitative application of principles.

KAZEM, AHMED K. An Experimental Study of the Contribution of Certain Instructional Films to the Understanding of the Elements of Scientific Method by Tenth-Grade High School Biology Students.

Problem.—To determine the effectiveness of two different types of selected films upon the understanding of the elements of scientific method by 10th-grade high school biology students enrolled in first-semester college preparatory biology classes.

Procedures.—Two types of films were shown: informational expository, *The Scientific Method* and *Using the Scientific Method*; and historical dramatic, *Madame Curie* and *Pioneer of Flight*. Four public high schools in Detroit participated. Four college preparatory biology classes participated: (1) Experimental class I, viewing the two informational expository films; (2) experimental class II, viewing the two historical dramatic films; (3) experimental class III, viewing the film, *Using the Scientific Method* and also the film, *Madame Curie*; and (4), a control class which viewed none of these films. A test devised by O. P. Keeslar was administered as a pre- and posttest. Four matched groups were established by matching individual students according to grade level, achievement on the pretest, intelligence, reading ability, sex, chronological age, and school. Comparisons between the groups were made in the mean scores on the posttests. The differences between means were evaluated for their significance, using the critical ratio test and the *t*-test.

Findings.—(1) The informational expository films, the historical dramatic films, or the two in combination contribute significantly to increased understanding of scientific method. (2) The informational expository films made a significantly greater contribution to an understanding of the elements of scientific method than those of the historical dramatic films.

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KOELSCH, CHARLES L., and 1958-59. A Seven State Project. Equipment Available for Teaching Science in Public High Schools, 1958-59. A Seven State Project.

Problem.—To survey the facilities and equipment available for teaching high school science in 1958-59, in relation to enrollments and size of school.

Procedures.—A random sample, representing 25 percent of the schools in seven States, was selected for study. An on-the-spot inventory was made of the facilities and equipment in each school together with pertinent enrollment data. A total of 855 schools were studied. An interview questionnaire was used to collect the data. Data were placed on IBM cards, and reliability was checked by the chi-square method. Data on school enrollments, science enrollments, science offerings, presentation (classroom) and laboratory facilities, general provisions for procuring equipment, and equipment inventories were analyzed.

Findings.—Of the number enrolled, 24.5 percent studied biology, 10.2 percent chemistry, 5.6 percent physics, or 40.3 percent studied one of the three sciences. Many schools had inadequate facilities and equipment for teaching science; but the large schools generally had better classrooms and laboratories than small schools. About 60 percent of the schools had annual budgets for science equipment. Large schools had larger budgets than small schools but less per student. The average budget per student was \$2.66 per year. School budgets were more adequate for nonacademic programs than for science equipment.

LEE, DONALD E. An Evaluation of Certain Objectives of High School Physics With Reference to the Training of Future College Physics Majors and the General Education of All Students.

Problem.—To determine the extent to which it is possible or desirable, in a single physics course, to teach for the college preparation of pupils who will later become physics majors in college and for the general education of other pupils.

Procedures.—A master list of specific content and behavioral objectives of high school physics was developed. These were evaluated by general physics professors and general physics students to establish their importance for physics majors in college. Science educators and laymen evaluated these objectives as to their importance for general education. The questionnaire technique was used to collect data.

The Friedman Two-Way Analysis of Variance indicated that none of the juries was especially reliable in rating the objectives on an absolute standard. The Kendall Coefficient of Concordance, however, showed that the ratings of a given jury were reliable when the relative importance of the objectives was measured. This same test was used to determine the relative importance of the items as measured by one jury compared with the determination made by other juries. The Kolmogorov-Smirnov One-Sample Test was used to compare the distribution of the actual ratings for each item with an expected random distribution for each jury.

Findings.—Statistically, the relative importance of the specific objectives of high school physics seems to be the same for the education of future physics majors in college as for the general education of all students. The chief discrepancies centered on the relative importance of several highly fundamental items dealing with "pure" physics and other items applying principles to everyday situations. Those items dealing with the scientific method and attitude were clearly considered to be of greater importance than were the specific items of content.

LIGHTNER, JERRY P. The Status of Advanced Biology in Large Secondary Schools of the United States.

Problem.—To determine the status of advanced biology courses in large public and nonpublic secondary schools in the United States.

Procedures.—The descriptive survey method was used in two surveys. First, the survey included all public secondary schools with enrollments over 1,000 students and nonpublic secondary schools having 70 or more graduates. A 92.6-percent return from the 1,217 schools surveyed resulted in a list of 342 advanced biological science courses offered by 276 schools. Of these courses, 171 were selected by title as being advanced biology courses. In the second survey, a questionnaire on advanced biology was sent to the chairmen of the biology departments of 171 of these schools. It contained 157 items on 6 major areas: (1) the purpose of the course; (2) books and reading materials; (3) major subject-matter content areas; (4) manner of programing; (5) extent of student research; and (6) status of the teacher. One hundred and thirty-five complete and usable questionnaires representing a 78.9-percent return constituted the source of the data for the report on the status of advanced biology in large secondary schools.

Findings.—(1) Eighty-five percent of schools offered advanced biology as a college preparatory or preprofessional course. (2) Three-fourths of the courses used a college-level general biology textbook. (3) A comprehensive study of the following topics was undertaken in these courses: (a) major vertebrate systems in 81.2 percent, (b) genetics in 74.4 percent, (c) cell division and biological growth in 69.6 percent, (d) cell structure and function in 45.1 percent, (e) cellular biochemistry in 37.9 percent, (f) structure and function of invertebrates in 36.7 per-

cent, and (g) structure and function of plants in 35.8 percent. (4) Average class size was 23.5 students; students spent an average of 285 minutes per week in scheduled classroom and laboratory periods. (5) Research projects were undertaken in 88 percent of the courses. (6) Eighty percent of the teachers had graduate degrees; 75 percent had taken college work within the past 5 years; the average teaching experience was 18 years.

Some advanced biology courses did not undertake a study of all subject matter areas commonly ascribed to the field of biology. At least one-half of secondary school advanced biology courses were equal in course content to beginning college-level courses. Advanced biology was being taught by well-prepared, professional teachers.

MACCURDY, ROBERT D. Science Interest Grows.

Problem.—What has been the effect of the beginning of the space age on science interest? Does science interest change in young people over a 4-year period? Are there regional influences on science interest?

Procedures.—R. M. Thompson and R. D. MacCurdy published a report, "The Birth of Science Interest" in *School and Society* 85: 56-57, February 1957. At 2-year intervals, the experiences, as reported previously, were repeated at State science fairs in two other States. The data were tabulated and studied to compare the results in three different regions in the United States over a 4-year period. Certain questions were asked in an interview during the public observation time at the three separate fairs. Responses were collected on identical forms and tabulated. The tables were studied to discover any trends or general choices. The responses were reported in simple frequencies and not in percents because the respondents provided multiple answers, no answer or one answer and in many cases did not give a single answer.

At times the response was *either, or*, and occasionally *neither*.

Findings.—First science interest appeared to have personal, solitary, sensory, wonder-provoking, and free-play qualities. This interest occurs from age 7 to age 13. Occupational choices at a later age are closely related to first science interest. These have shown a strong trend in favor of physical science occupations. The persons having the greatest influence on the child's first science interest were his teacher and his father. The diversity in science-related items and activities available both at home and at school was lower in the 1957 and 1959 surveys than in 1955.

MACCURDY, ROBERT D. Scientist or Engineer?

Problem.—To determine factors related to success in these two groups, and factors that influence the occupational choices in young men who contemplate these fields.

Procedures.—A group of 504 honors winners in the Science Talent Search of 1952 and 1953 participated in the study. Included were subgroups of 110 and 164 who had chosen engineering and science, respectively, as careers. Reactions of these subgroups and a control group to questions were compared statistically. When reactions of the subgroups differed from each other or the control group at the 5-percent level, the response was considered characteristic of that group or subgroup. The responses were collected and studied in the following categories: Occupational choice, personality, interests, activities, attitudes and opinions, family history, associates, and influence of science teacher. There were over 50 contrasting characteristics that set these 2 subgroups apart.

Findings.—The potential engineer was a socially oriented person who enjoyed working with other people, liked to work with his hands, and felt that science was for man's use. He derived much satis-

faction, encouragement, and help from his family and associates, and from publications. The potential scientist was a solitary individualist who finds satisfaction in complex, intellectual, nonsocial activities. He considers the search for truth the most important activity for man.

MARK, STEVEN J. Experimental Study Involving the Comparison of Two Methods of Performing Experiments in High School Chemistry.

Problem.—To compare the results of two different methods of teaching chemistry during laboratory periods.

Procedures.—Six high schools located within a radius of approximately 30 miles from Kent State University in Ohio participated in the study. An experimental and a control group were formed in each school. The control group consisted of students who performed 10 experiments according to directions found in most current laboratory manuals. The instructor discussed with this group the 10 experiments and the textbook assignments before they experimented in the laboratory. The students recorded their results on the blanks provided in the manuals. The experimental group consisted of students who devised methods of solving problems given to them before a discussion of that particular phase of work in the classroom. The problems were identical to those given to the students in the control group. Their results were recorded on special experiment sheets in the form of actual observations, equations, calculations, diagrams, and conclusions. During the second semester, each of the six instructors administered the Chemistry Aptitude Test, Form M, to both groups. The test was given to determine whether the two groups differed significantly in their abilities to succeed in high school chemistry, and to determine whether the students differed significantly in their abilities to read and

comprehend facts in the field of chemistry after one semester.

After the 2 groups in the 6 schools performed the 10 experiments, the Cooperative Chemistry Test, Form Z, was administered. This was designed to measure the acquisition of unrelated chemistry knowledge, and to determine the students' abilities to interpret chemistry knowledge stated in the form of paragraphs and diagrams.

Findings.—At the beginning of the study, the groups did not differ significantly in their abilities to succeed in high school chemistry nor in their abilities to read and comprehend facts in the field of chemistry after one semester. The results of part I of the Cooperative Chemistry Test, Form Z, revealed that both groups did equally well in the mastery of unrelated chemistry content. When the results of the tests for the two groups were compared for part II, the statistical data indicated that the experimental group surpassed the control group in interpreting chemistry knowledge expressed in paragraphs and diagrams at the 3-percent level of confidence.

MARSHALL, J. STANLEY. The Relationship Between Readability and Comprehension of High School Physics Textbooks.

Problem.—To determine the relationship between the readability and comprehension of high school physics textbooks.

Procedures.—Two groups of high school physics students, equated on reading comprehension and physics aptitude, were used in the study. The first group read a physics passage from one of the standard textbooks commonly used in the high schools of the State of New York. The second group read a reconstructed version of the same passage by having its readability score altered as determined by the Flesch Reading Ease formula. Both groups were then given the same test of comprehension covering the passages. Finally, the scores of the two groups were compared and analyzed.

Findings.—The analysis of data showed that the students who read the rewritten passage did not perform significantly better on the test of comprehension than did the students who read the unaltered textbook passage. The Flesch Reading Ease formula does not predict difficulty in the comprehension of high school physics textbooks.

MAUL, RAY C. Teacher Supply and Demand in Public Schools, 1960.

Problem.—To obtain an up-to-date nationwide overview of the supply and demand for teachers of every grade and every subject in the elementary and high schools of the Nation.

Procedures.—This is an annual nationwide study conducted by an appropriate officer in each of the 50 State departments of education. One part of the study is based on reports by registrars of all degree-granting institutions in the States. These reports show the number of seniors who will become eligible for teaching positions according to their major fields of preparation, including those prepared to teach biology, chemistry, elementary science, general science, physics, physical science, or any combination of these subjects. Another part, based upon reports by college placement officers, shows the number of the preceding year's eligible graduates who actually accepted teaching positions, and the occupations attracting those who did not enter teaching. A third part of the study, based upon reports by local school districts to the State department, identifies each new teacher according to his teaching assignments.

Findings.—(1) The supply of college graduates prepared to teach the sciences has been, and continues to be, far below the needs of the schools. (2) Many college graduates prepared to teach science are attracted to other occupations, the annual loss ranging from 30 to 45 percent. (3) School districts, through lack of available qualified teachers, often fail to

offer instruction in one or more of the science subjects. (4) Many districts assign unprepared teachers to science subjects.

NELSON, KENNETH G., and MILTON O. PELLA. Evaluation of the Adapted Harvey White Physics Films in Turkey.

Problem.—To determine the feasibility of using the Harvey White Physics Films in improving the teaching of physics in the secondary schools of Turkey.

Procedures.—An experimental group of 1,657 ninth-grade students in 6 lycees was divided into 4 subgroups: (1) Experienced teachers using the films and associated materials, (2) inexperienced teachers using the same materials as in the experienced teacher group, (3) correspondence study groups using a prepared self-study course that included the films, and (4) experienced teachers using the translated textbook but not the films. The control group of 756 students represented the enrollment of a boys' lycee and a girls' lycee in Ankara. Achievement of students and teachers was determined by objective achievement tests adapted from items used in the Wisconsin Physics Film Evaluation Experiment. Analysis of variance was used in testing for the significance of differences in achievement. Student attitude was obtained by a questionnaire, and science interest was measured on a before and after basis by a forced-choice instrument. Teacher knowledge was measured by the College Cooperative Physics Test, and teacher opinion and attitude was gathered by a combination objective and open-end questionnaire.

Findings.—(1) The achievements of the two groups, using experienced and inexperienced teachers, were not significantly different at the 5-percent level. High ability students achieved more with experienced than inexperienced teachers. (2) The achievement of pupils not using the films was significantly greater (5 percent level) than those using the films.

(3) Students with the experienced teacher using the films achieved higher final test scores (5 percent level) than those taught by a film series correspondence course. However, boys in the two groups did about equally well, while girls with experienced teachers did better than those in the correspondence course. (4) It seems that inexperienced teachers with little or no knowledge of physics increased their competence in physics while teaching this film series course. The experienced teachers also gained a better understanding of the subject.

ORLICH, DONALD C. Teaching Science in Montana Senior High Schools.

Problem.—To determine the status of methods of teaching science in senior high schools in Montana.

Procedures.—A library search yielded information concerning current trends in methods of teaching science. The investigator compiled a list of criteria of the methods that were desirable in the science courses. An 8-page questionnaire was mailed to one teacher, selected at random, in each of the 190 public and private high schools in Montana. The number returned was 81.5 percent, representing 93 percent of the counties. An appraisal of the methods of science teaching used in the State was made by using the criteria developed from the literature.

Findings.—(1) The types of development of the science programs in order of frequency were the use of textbook as guide, unit plan, and resource unit. (2) The teaching methods most frequently used were demonstrations, lectures, individual reports, science fairs, field trips, homework, discussion of community problems, teacher-constructed tests, and studying about science careers. (3) Laboratory periods were generally conducted in all sciences taught, except general science. Forty-one percent of the schools did not have a laboratory period for general science. (4) Montana science teachers disagreed, by a 3-to-1 margin, with the trend

to allow students to help plan science courses. Montana science teachers tended to be traditional in their teaching methods, since more progressive methods such as individual laboratory work were generally lacking. (5) The lack of laboratory equipment was one of the main shortcomings in the science programs included in the study. General science was a reading course in almost half of the schools.

OZINONU, AHMET KEMAL. Integrating Recent Scientific Concepts Into the Nine-Grade Science Curriculum.

Problem.—To study the meaning of concept and to identify basic concepts in certain areas of science; to integrate these scientific concepts in ninth-grade science instructional units; to determine the effectiveness of the new subject-matter content by putting it into an actual teaching-learning situation; and to analyze the results and observations obtained.

Procedures.—The instructional units were organized around certain basic "observables." The topics within each unit were arranged so that the educational activities involved would help the students develop first a percept, then qualitative, quantitative, and abstract concepts of the particular phenomenon examined. The effectiveness of the new content was tested with a group of high school freshmen for 55 class sessions of experimental teaching. The average IQ of the experimental group was 134, with a chronological age average of 13 years 8 months. The development of the basic concepts and of related factual knowledge of the subjects was determined as the mean difference between their pre- and post-testing achievement scores obtained by the use of three measuring tools prepared by the investigator. Science Form 3A of the Cooperative Sequential Tests of Educational Progress and Science Test IV, Data Sheet and Individual Information Blank were also administered. Along

with the statistical analysis of the effectiveness of the new subject-matter content, class sessions, and some special sessions during the experiment were recorded on tape and then analyzed descriptively.

Findings.—The subjects who participated in the experiment developed the basic scientific concepts in the areas tested by Concept I and II tests. (Significant at 0.01 level for Concept I, and substantially close to 0.05 level for Concept II test.) Along with their development of the basic concepts, the subjects gained basic scientific knowledge in the areas tested by General Science Test. (Significant at 0.01 level.) Because of their close contact with new and different science topics, the subjects' interests were broadened and varied. Throughout the study, the members of the experimental freshmen science group indicated a positive attitude toward the new subject-matter content. In their response to a questionnaire, some students showed a strong desire to continue educational activities related to the new content. Some students designed, developed, and carried on individual projects related to the areas of the experimental curriculum.

PLOUTZ, PAUL F. The Science Supervisor.

Problem.—To determine the science supervisor's conditions of employment, status, and professional responsibilities.

Procedures.—Data were gathered by questionnaires from 100 supervisors of science at 4 levels: elementary (grades 1 through 8), K-12 (kindergarten through grade 12), secondary (grades 9 through 12), and State. The 100 supervisors participating in the study were a highly select group, representing both part- and full-time supervisors from both large and small districts in 32 States, with greater consideration for regions of dense population.

Findings.—Supervisors at all levels spent most of their time (in descending or-

der of frequency mentioned) in (1) assisting teachers in the classroom; (2) providing materials, supplies, and information; (3) developing curriculum; (4) organizing programs with department heads, principals, and superintendents; (5) providing inservice education; (6) teaching demonstration classes; and (7) administering the National Defense Education Act. The data revealed 31 similarities of conditions of employment, status, and professional responsibility common to supervisors at the four levels.

The following recommendations were given by science supervisors to present and future elementary, K-12, secondary, and State supervisors for the improvement of science education in the United States:

1. Develop good working conditions with teachers and administrators by being patient in effecting change, demonstrating leadership and not interference, and realizing that science is one of the areas of the instructional program.
2. Prepare both in science content and education, to discuss intelligently, to assist, and to demonstrate ability in all of the science areas.
3. Stay up to date by encouraging and being active in the local, State, regional, and national organizations devoted to science.
4. Develop and work for the objectives of the science instructional program with teachers by developing curriculum, securing funds for materials, equipment, and supplies.
5. Work for teaching by problem-solving techniques and quality of concept rather than textbook or memory instruction.
6. Continually work for and maintain a continuous grade-to-grade science instructional program, each teacher aware of what others are doing insuring on a vertical K-12 science sequence.

POTTER, DONALD GLENN. Extra-Class Science Activities in Accredited Colorado High Schools and Their Relationship to Certain Measures of Student Interest in Science.

Problem.—To evaluate extraclass science activities (1) as a means of creating interest in science during the high school years, and (2) as a stimulus toward making a career in science.

Procedures.—Through the use of a questionnaire to 243 accredited high schools in Colorado, information was gathered concerning science clubs and fairs. Fifteen schools reporting science clubs were matched as nearly as possible with 15 schools that had no clubs. The investigator visited the 30 schools and administered questionnaire forms to students, interviewed teachers and other school personnel, and surveyed science and library facilities.

Findings.—The high school questionnaire returns indicated that 56 percent of secondary pupils in Colorado were taking some work in science, with the greatest enrollments in biology and general science. Over 17,000 students were in high schools, primarily multiple curricular, which did not require science for graduation. Only about 5 percent of the students were in extraclass science activities. Approximately one-half of the students completing questionnaires planned to attend college and about one-third were planning scientific careers, but only 11 of the 560 planned to be teachers. The student questionnaire and teacher interviews indicated that teacher time and interest seemed to be the essential requirement for successful clubs. Only 8 teachers in the 30 schools rendered full-time services to science teaching, 13 had responsibilities in coaching, and 9 had outside employment to supplement their income.

RABB, DONALD DRUM. The Selection of Principles Regarded by Persons Involved in Teaching and

Learning as Fundamental for Tenth-Grade General Biology.

Problem.—To determine what principles are fundamental in constructing a 10th-grade general biology course for all students whether or not they are going to college, and regardless of their choice of occupation.

Procedures.—A list of 100 principles of the biological sciences of importance for general education was selected as a basis for the investigation. The list was revised to reflect the findings of recent research. The resulting list of 65 principles was then incorporated into a checklist questionnaire and distributed to 4 sample groups in Pennsylvania to determine appropriateness for inclusion in a 10th-grade general biology course, including both terminal and college-preparatory students. Questionnaires were returned by 42 college biological science educators, 134 secondary biology teachers, and 77 recent alumni of 3 selected high schools, and 164 college students.

The responses to each principle in the three categories, *essential*, *desirable*, and *unnecessary*, were converted into a numerical value or index number by the use of a weighting formula. The principles were then ranked in order of their importance as rated by each of the responding groups. The primary objective of investigation was the determination of a final ranking of the 65 principles on the basis of the evaluations of the 4 sample groups. A statistical analysis was made to determine the extent of the influence of chance in the obtained results, the degree of correspondence between the responses of the four sample groups, and the significance of the data.

Findings.—Comparison of the emphasis of topics established in the present study with recent investigation of the emphasis usually given topics in high school general biology suggests that (1) greater emphasis should probably be given the topic *Reproduction* than is now being afforded; (2) the current high emphasis

given the topic *Protoplasm and Cells* and *Physiology and Morphology* is justifiable; and (3) the major emphasis placed on the topic *Genetics* is probably greater than it should be. Except for a few items in which there was a marked difference of opinion, there was a high degree of correspondence in the rank assigned the various principles by the four groups investigated. The degree of correspondence was greatest between the closely allied samples such as the two teacher groups and the two student groups.

The secondary biology teachers had a marked tendency to rank more of the principles as *essential* than any of the groups investigated. Major emphasis in constructing a course of study in general biology should be given the principles that come under the following topic headings arranged in order of emphasis: (1) Reproduction, (2) protoplasm and cells, (3) physiology and morphology, (4) organization, (5) energy and matter, (6) ecology, and (7) genetics.

RICHARDSON, BELLOWS, HENRY & Co., INC. A Look at the 1959 National Science Foundation's "Summer Science Training Program for High-Ability Secondary School Students."

Problem.—To evaluate all phases of the National Science Foundation Summer Science Training Program for High-Ability Secondary School Students by means of scientist visits and other methods to suggest a plan for the continuing and long-range followup of this and future National Science Foundation SST Programs.

Procedures.—A sample of 11 summer science programs drawn from a population of 117 matched the total in terms of subject matter, research opportunity, and residential arrangements. The 418 students (grades 8 to 12) attending these 11 summer science programs constituted the sample. Scientist-educator observers visited each of the 11 programs, interviewing directors, staff members, and

students and generally scrutinizing the program in detail. Following a rigid schedule, observers dictated reports covering each visit. Students filled out two questionnaires, one dealing with the background history of the student and his future plans, the other probing students' opinions concerning the summer experiences. Observers' reports were analyzed and consolidated into a single descriptive report. Student responses to the questionnaires were tabulated to provide statistical descriptions of the student body and quantified indications of their feelings concerning the summer science program. An advisory committee made up of observers and scientists from the National Science Foundation met with the consultants on two occasions to discuss findings and conclusions.

Findings.—The summer science program experiment appeared to be a vast one, but one which could be conveniently dealt with under the following headings: Program objectives, type of program, staffs involved, teaching methods and procedures used, facilities available, recruitment and selection of students, student performance, special problems encountered, financing, general considerations, and plans for program followup. Marked variety was discovered in each of these categories indicating the highly unstructured nature of the summer science program as a whole.

In the opinion of student participants, the program was a decided success. Certain individual programs seemed to have more impact on students than others, and certain aspects of the total program seemed to be more popular and effective than others. Data were used in making comparisons with other student groups. Analysis of these data revealed that the participants were a highly selected group.

The summer science program was a new but highly promising one. Because of its potential as a stimulator of interest in and motivator toward science as a career, it was urged that this program be continued and enlarged.

SILOVSKY, GEORGE J., and KENNETH E. ANDERSON. A Study of the Relationships of Nonacademic Correlates to Achievement—Participants and Nonparticipants in the National Merit Scholarship Testing Program.

Problem.—The purpose was threefold. First, the writers attempted to discover the circumstances and conditions which apparently influenced some pupils of superior ability to a high level of accomplishment; and secondly, attempted to correlate certain nonacademic factors with the Humanistic Composite Scores and the Science Composite Scores achieved on the National Merit Scholarship Test, and to ascertain whether these correlations showed any significance at the 1-percent level. Lastly, to ascertain whether there was any significance at the 1-percent level between participants and nonparticipants in these non-academic factors.

Procedures.—During the spring of 1958, about 7,000 high school students in over 300 secondary schools in Kansas completed the National Merit Scholarship Test. During the school year 1958-59, when some students were asked to complete an eight-page questionnaire, five students in each school who had not taken the test were also asked to complete the questionnaire. The students were called participants and nonparticipants. The final returns show about 4,675 questionnaires for the first group and about 1,028 questionnaires for the second group. Included in the questionnaire were three sets of items pertaining to nonacademic correlates of achievement: *parental, educational, and intellectual curiosity and persistence*. Fifty schools were selected at random for an exploratory study of the three sets of items. For each non-participant a participant was chosen at random from that school. The sample consisted of 100 participants and 100 non-participants. The Science Composite Scores and Humanistic Composite Scores

on the National Merit Scholarship Qualifying Test were recorded. Three *t*-tests were run to ascertain the existence of significant differences between the participants and nonparticipants on the three sets of non-academic items.

Findings.—The results suggest that the students who aspired to a National Merit Scholarship, or who were sufficiently motivated to take the test, tended to score themselves significantly higher on the self-evaluating (Intellectual Curiosity and Persistence) items than did the non-participants. Positive and significant correlations were obtained between the self-scores on these items and the Humanistic and Science Composite Scores on the National Merit Scholarship Test. It would seem that high ratings on two sets of items, parental and especially self-evaluating, tend to be accompanied by high achievement scores in the humanistic and science areas.

SMITH, RICHARD N., A. C. ANDERSON, LEROY PRATT, and MARVIN INGLE. Science in Iowa High Schools.

Problem.—To discover (1) the number of units of science offered or required in the Iowa schools, (2) the nature and level of science courses offered, (3) the number of pupils enrolled in science courses, (4) the qualification of science teachers and their teaching loads, and (5) equipment and facilities available for science instruction.

Procedures.—A questionnaire was sent to 1,322 science teachers in the 614 approved 4-year public high school districts in Iowa for the school year 1959-60. Data were collected on the units of science offered, courses offered, enrollments, qualifications and assignments of teachers, and equipment and facilities. The number and percent of school districts, schools, teachers, and pupils were reported.

Findings.—(1) The mean number of units of science offered was 3.3. (2) General science, biology, chemistry, and

physics were most commonly offered in grades 9-12. (3) Fifty-seven percent of all students were enrolled in science courses, most frequently general science and biology. (4) Science fairs were held in 28.7 percent of the high schools, and science clubs in 21.3 percent of the school districts. (5) Fifty-three percent of the teachers sampled have science majors, 37.4 minors, and 9 percent have neither. (6) Twenty-five percent of science teachers subscribe to *The Science Teacher* and 5.5 percent to *School Science and Mathematics*. (7) Forty-one percent of science teachers teach science only; 26 percent teach 5 periods or more of science per day.

STARING, LUCY L. The Status of Secondary Science Teachers of Louisiana 1956-57.

Problem.—To determine the status of the science teachers of Louisiana by (1) size of the school, (2) subjects taught, (3) certification, (4) types of certificates held, (5) college degrees, (6) experience, (7) college preparation in science, (8) sex, and (9) race.

Procedures.—Data were secured from records in the Louisiana State Department of Education. After the data were assembled, they were processed by the IBM office at Louisiana State University. To be classified as a science teacher, a teacher must teach at least one class of either biology, chemistry, physics, or general science.

Findings.—The study revealed that over 70 percent of the white science teachers in each science field were certified. General science teachers showed the highest percentage of certification. Almost 20 percent of these teachers had less than 4 years' experience. Over 35 percent had less than 5 years' tenure in their present positions. Approximately 70 percent of the white science teachers were men. Bachelors' degrees were held by 66.7 percent of the teachers. Over 40 semester-hours of college science were reported by 17 percent of these teachers. No college

work in science was shown by 0.7 percent.

For the Negro science teachers, more than 70 percent in each science field were certified. Over one-fourth had less than 4 years' teaching experience, and 41.8 percent had held their present positions less than 4 years. There were two men for each woman teaching science in the Negro schools. Bachelors degrees were held by 84.3 percent of these science teachers. Over 16 percent of the Negro science teachers had more than 40 semester-hours of college science.

STREVELL, WALLACE H. The Effectiveness of Teaching High School Physics by Television as Determined by Certain Varied Conditions.

Problem.—To compare the effectiveness of teaching physics by television under combinations of the following conditions: Homogeneous, heterogeneous, rural, city, Negro, white, and control classes. Also, to develop working relationships with school districts and investigate team teaching with television.

Procedures.—A course in modern high school physics was taught directly by television to 315 high school seniors in 15 school districts. Regular physics teachers were used in teaching teams in 22 experimental classes. There were 31 control classes in 24 high schools. Lessons were planned cooperatively, outlines published, and television lessons given 3 days a week for the entire school year. Hypotheses involved homogeneous and heterogeneous groups, urban and rural classes, white and Negro segregated classes, and several other measurable conditions including school organization and methods of team teachers. The tests used were Otis Mental Ability, Iowa Physics Aptitude, Outterson Physics Mid-Term, and Dunning Physics Achievement. Data were also secured from questionnaires, observations, and interviews. The results for major hypotheses were treated with analysis of variance. Other conditions were evaluated through gain in

actual student achievement over predicted rate of achievement by matched pairs.

Findings.—(1) Learning by television was more effective (1 percent of significance) in homogeneous classes than in heterogeneous classes under conditions of the study. (2) In the first year of TV instruction in the participating school districts, learning of physics by television was as successful as in the traditionally taught control classes. (3) Television teaching proved to be an advantage for the academically underprivileged, rural, or Negro groups. (4) Although the attitude of team teachers had a significant relationship to student gain, it was concluded that the technique of team teaching is the primary condition needed for effective television teaching.

THELEN, LEVERNE JOHN. Facts and Concepts of Chemistry of Importance for Introductory High School Biology.

Problem.—To identify and state those facts and concepts of chemistry which, in the opinion of the investigator, might be necessary to understand the biological phenomena considered in certain selected typical biology curriculum materials and to determine the relative potential importance of each stated fact and concept of chemistry to the understanding of introductory high school biology.

Procedures.—The investigator examined 22 textbooks, 18 workbook laboratory manuals, 23 curriculum guides, and 23 films to determine those facts and concepts of chemistry which might be necessary for the understanding of biological phenomena. A suitable evaluation instrument was developed and sent to a panel of experienced biology teachers who rated each concept to be *very important*, *fairly important*, or *of little or no importance* to the understanding of introductory high school biology. Numerical values were assigned to the ratings and the mean value calculated for each fact or concept. On the basis of the calculated

mean value, each fact or concept was then rated.

Findings.—There were 511 facts and concepts of chemistry identified, which, in the opinion of the investigator, might be necessary to understand the biological phenomena considered in certain selected typical biology curriculum materials. On the basis of the evaluations by the judges, 149 facts and concepts were designated as being *very important* for the understanding of introductory high school biology; 259 as being *fairly important*; and 103 as being of *little or no importance*.

TROWBRIDGE, LESLIE WALTER. A Comparison of the Objectives of Traditional High School Physics With the Objectives of the Physical Science Study Committee Course, and an Analysis of the Instructional Materials of the Physical Science Study Committee Course.

Problem.—To compare the objectives of traditional high school physics with the objectives of the Physical Science Study Committee course, and to analyze the instructional materials of this study committee course to determine their relevance to the stated objectives.

Procedures.—Objectives of the PSSC course and of traditional physics were compiled. A list of 72 objectives of high school physics teaching was formed, 17 were unique PSSC objectives, 17 were unique traditional objectives, and 38 were joint objectives. A questionnaire, based on these objectives, was sent to random samples of 100 PSSC teachers and 100 traditional teachers in the 19 North Central Association States. Data were analyzed by the chi-square test of significance. The instructional materials of the PSSC course were analyzed at two separate times, 2 months apart, by use of a rating scale designed to assess the degree of incorporation of the objectives in the instructional materials.

Findings.—(1) Both courses were found to have several unique objectives as well as many joint objectives. (2) PSSC teachers and traditional teachers tended to adhere strongly, both in agreement and practice, to the objectives identified as unique to their respective courses. (3) Teachers of both courses were strongly affected by school enrollment, years of physics teaching experience, and class size. (5) The analysis of the PSSC materials showed a strong adherence to the objectives unique to the course. Unique traditional objectives received little attention in the PSSC instructional materials.

VISHER, HALENE HATCHER. A Determination of Conservation Principles and Concepts Desirable for Use in the Secondary Schools.

Problem.—To determine the principles and concepts of conservation desirable for use in the secondary schools, grades 7 through 14, inclusive.

Procedures.—A list of principles and concepts was obtained by an analysis of 15 conservation textbooks, 9 books for the general reader, 2 special conservation issues of journals, 1 reprint series, 3 publications of professional materials for teachers, and 4 doctoral dissertations. The tentative list of generalizations was submitted to 11 specialists representing a wide range of professional training and experience in conservation. The resulting list of principles and concepts was submitted to five nationally recognized leaders in conservation education familiar with instructional problems at the secondary school level. These persons evaluated each statement in terms of its relative desirability for use in the secondary schools.

Findings.—The approved list of 477 conservation principles and concepts constitutes the major contribution of this investigation. These generalizations include 78 classed as general or not limited to a single resource; soils include 85; forests, 55; grasslands, 20; minerals, 57;

wildlife, 51; recreation and scenic resources 37; and human resources, 38.

WALTERS, LOUIS L. A Comparison of Achievement in High School Biology When Taught to Ninth-Grade and Tenth-Grade Pupils.

Problem.—To compare the achievement of 9th- and 10th-grade students in high school biology.

Procedures.—Ninth-grade students entering in 1957 were randomly assigned to three groups, one group studying biology that year, the other groups taking the course the following year as 10th-grade pupils. Similarly the 1958 ninth graders were assigned to three groups, two of which studied biology as ninth graders and the other in the 10th grade in the 1959-60 school year.

Findings.—It was concluded that when a full range of abilities are represented in a class, biology could be taught in the 9th grade as effectively as in the 10th grade and that talented or lower ability 9th-grade students achieved as well as similar students in the 10th grade.

WESTMEYER, PAUL. Development and Preliminary Trial of a Method of Teaching Chemistry.

Problem.—To develop and evaluate a method by which the self-direction of students in investigating chemical problems can be improved.

Procedures.—The developed method of teaching chemistry involved development of teacher-directed study at the beginning of the course; studies planned by the class and teacher and by small groups of students during the middle portion of the course; and studies planned by individuals under the guidance and supervision of the teacher near the close of the course. Data for evaluation of the method as a means of attaining the stated objective were collected by (1) compiling detailed case studies of 10 students, (2) rating students at midcourse and at the end of the course on manifest problem-solving

ability, and (3) administering a pre- and posttest on interpretation of data in chemistry. Tests of factual achievement were also used. Ratings of students on self-direction and on problem solving were made by the instructor and an assistant who was employed to help with the evaluation. The detailed case studies were compared, and the ratings and test data were analyzed by *t*-test, chi-square, and rank correlation procedures. For the test of factual achievement, the norm group of the standardized factual achievement test was used as a control.

Findings.—The development of self-direction was found to be related in a positive way to improvement in manifest ability to solve laboratory problems, improvement in manifest ability to interpret data, rating at the end of the course on problem-solving behavior, development or maintenance of personal interest in course content and proceedings, experience in small-group planning and execution of experiments, social acceptance in the class, and general level of intelligence. The evidence supports the conclusion that students can be expected to develop some degree of self-direction in a course of this type without any appreciable sacrifice in factual achievement.

YON, JOHN F. The Academic Year Institute for High School Teachers of Science and Mathematics at The Pennsylvania State University During the 1957-58 Term.

Problem.—To determine the values derived from participation in the 1957-58 Academic Year Institute at The Pennsylvania State University.

Procedures.—Questionnaires were administered to the members of the Academic Year Institute at the initiation of the program in the fall of 1957, at the conclusion of the institute in the spring of 1958, and in the classroom in the spring of 1959. The reactions of the members themselves were supplemented by an-

swers to questionnaires sent to principals of the schools where these teachers had taught during the school year 1956-57. Answers given by the principals were checked against those of the institute members to ascertain the extent of agreement. Information was also secured by telephone conversations and personal interviews with almost one-third of the participants in the study and further correspondence with about one-half of their number.

Findings.—The Academic Year Institute was recognized as having value for the participants, the schools where they taught, and the communities in which they lived. Personal gains were listed as advancement in professional status, advancement in position, attainment of individual goals, gain in prestige, acquisition of the background material necessary to do a better job in the secondary school science and mathematics instruction, and satisfaction with the teaching role.

The science and mathematics programs in the public schools received a boost as these teachers promoted them in various ways by (1) delivering talks to student groups; (2) organizing clubs and student engineering and science societies; (3) fostering curriculum revision within their schools; (4) explaining the results of the institute program to teachers at their meetings; (5) meeting with adult science and engineering groups and securing cooperation between them and the school program; (6) delivering addresses to public gatherings, and to some extent by radio and TV; and (7) engaging in other activities, such as writing newspaper and magazine articles, promoting science fairs, and helping with science workshops and institutes. The study showed further that teachers engaging in the institute secured advancements commensurate with the gain in education and that their interest in and enthusiasm for teaching in the fields of science and mathematics had been strengthened.

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Research Studies in College Science

IN THE BIENNIUM from July 1959 to July 1961, more than 100 studies were reported dealing with some facet of science education at the college level. From 1961 to 1963, an additional 63 studies were located. The 33 studies which have been abstracted from the 1959-61 studies are classified on the basis of the fields for investigation in science established by the National Association for Research in Science Teaching. Many of the studies could have been placed in more than one category. A few, particularly those in teacher education, also have implications for elementary or secondary school science teaching. Each study is reported only once, however, and any cross-referencing has been left to the reader.

Analysis

Studies Related to Public Policy.—Two studies which merit careful reading are one by *Strauss* and another by *Harmon*. In these studies of 1957 and 1958 doctorates, an analysis of converted IQ scores, high school rank, grades in high school science and mathematics classes, and data on size of graduating class and geographic location were punched on IBM cards. The studies indicated large differences in IQ, high school rank, and grades between Ph. D.'s in different subject fields. The relative rank on all criteria was in the following order: Physical sciences, social science, humanities, biological sciences, and education. There is a strong positive correlation between size of high school and doctorate productivity, except in education. The evidence suggests that talent segregates into various fields, probably in relation to the relative intellectual appeal of these areas in high school and college classes, not in relation to the relative complexity of problems in these fields. The implications have significance for curriculum planning, especially in biology and college education fields.

Lee found personality differences among 66 future science teachers and 61 future research workers with the latter less "person-oriented."

A number of other studies related to public policy indicated such findings as (1) small colleges produce a disproportionately large percentage of research chemists (*Hirsch*); (2) scientists are more interested in explanation of natural phenomena than social science workers who are more interested in assisting others with personal problems (*Brizee*); (3) students respect the scientist's intelligence, but regard him as socially nonconformist (*O'Dowd* and *Beardslee*); and (4) college graduates of 1954 had 3.09 years of high school science, whereas 1941 graduates had 2.34 (*Tuckman*).

Studies Related to Curriculum.—There is a wide spectrum of studies dealing with the organization of special courses in science, importance of prerequisite course work, and development of special instructional material which can be grouped under the heading of curriculum.

Tuckman and *Etkin* compared the achievement on the Graduate Record Examination of college students enrolled in four 1-semester *Science Sequence* courses with the performance of matched groups enrolled in regular departmental courses. The value of prior course work in science was found to be significant statistically, but with a relatively small (10 percent) absolute gain attributable to such work. In summary, they concluded—

The data suggest that the particular science courses taken by liberal arts students are of less importance in the education process than curriculum makers commonly assume. It would seem that the factual content of a course (as measured by the Graduate Record Examination) can safely be relegated to a secondary position in curriculum planning and other course objectives given primary importance.

Meyer studied achievement of college chemistry students at the University of Nebraska and found: (1) Students with high school chemistry did better than students without high school chemistry (with ability difference controlled statistically) and (2) differences in final achievement of students in a 6-semester-hour more advanced course and those more poorly prepared students placed in a 10-semester-hour chemistry course were due primarily to differences in ability.

Dunbar and *Broberg* sent a questionnaire on graduate examination practices to 250 schools (84 percent return) having a chemistry department approved by the American Chemical Society. They summarized their findings and reported: (1) entering or qualifying examinations are standard practice in ACS-accredited schools; (2) increased emphasis is placed on undergraduate training including training in related fields; and (3) some schools use a nonthesis or nonresearch option at the M.S. or M.A. level.

Smith studied the performance of students enrolled in an introductory biology course at Tennessee Agricultural & Industrial State

University. Little correlation was found between high school grades in biology and achievement in the college course ($r=0.11$ to $r=0.39$). Correlation between intelligence and achievement was ($r=-0.02$) for students with "nonscience" interests. Although no indication of the significance of correlation coefficients was given, the data suggest that achievement in college general biology is related only slightly to high school performance in biology. Correlation with high school chemistry grades, however, ranged from $r=0.32$ to $r=0.69$. The data may suggest that the objectives of high school biology differ from those of college biology.

Eiss analysed the results of the science section of the Sequential Tests of Educational Progress given to 752 college freshmen and other data. He found: (1) essentially no difference in STEP scores among students who had taken 1, 2, 3, 4, or more high school science courses, and (2) little or no difference in scores on items of the STEP tests dealing with a specific subject, e.g., biology, of students who had taken and those who had not taken the high school science.

He concluded that a test emphasizing the ability to read and understand scientific information (as does the STEP test) will not show a correlation with past experience in typical high school science courses which emphasize memorization of bits of information.

Goddard studied tenure of graduate technical personnel in a selected chemical industry using 16 variables. Extracurricular activities, personality, part-time employment, and military experience were significantly related to tenure. Grades in college were not found to be related to supervisor's ratings. No combination of variables was found to have perfect correlation with tenure or supervisor's ratings, and continued study of selection procedure was recommended.

Studies Related to Methods.—*Lawson and others* developed a scrambled book to replace 1 week of laboratory work in an introductory college natural science course. The scrambled-book approach was used by 144 students, and achievement on a 30-item objective test was compared with that of a control group of 131 students. A significant difference in favor of the group using the scrambled book was found. Most of the students were favorably disposed to the scrambled-book approach and commented favorably.

What *Lawson* and his colleagues did was to select an area of biology in which the advantages of programed instruction are likely to be significant; this selection process *should not* suggest that *all* laboratory work should be discarded in favor of scrambled books. Moreover, making an effective scrambled book requires extraordinary imagination and skill plus hundreds of hours of concentrated work. It

should not be undertaken by anyone who can spend only an hour now and then on the project.

Kuhnen compared the relative value of field trips and laboratory work in college botany. The 112 students were divided into experimental and control groups based on laboratory instruction. Each group was experimental, using field work, and control, using laboratory work for 3-week periods. Gains in test scores were in favor of the laboratory approach. Student reaction to the field trips varied with some expressing enthusiasm and others preferring laboratory work.

Novak compared the achievement of college botany students divided at random into two groups, one group receiving labeled photomicrographs as a supplement to their regular laboratory guides. After 3 weeks of instruction the groups were reversed. No significant differences in means were found, but all differences were in favor of that group receiving supplementary labeled photomicrographs.

Experimentation in methods of teaching chemistry has been common for many years. The impetus provided by the American Chemical Society and the publication of reports in the *Journal of Chemical Education* may be partly responsible for this activity.

McMullen used a specially devised guide to "indoctrinate" students in the use of a five-step pattern of experiment planning based on suggestions in the literature. After an "indoctrination" period with four problems in chemistry, *McMullen* found concordance with the prescribed pattern in less than half of the student records, with individuals varying from zero to 100 percent concordance. No relationship was found between the degree of concordance and (1) ACE Psychological Examination percentile ranks, (2) ACE Test of Critical Thinking, and (3) ACS General Chemistry Test.

McPherson studied the effect of theoretical films and enrichment films (emphasizing applications) on the achievement of college chemistry students. He found no significant differences between matched groups having no films, theoretical films, or enrichment films for 13 weeks of instruction.

Botdorf compared the effectiveness of live chemistry demonstrations with the use of eight filmed demonstrations in college general chemistry. With 24 students in the live demonstration group and 23 in the filmed demonstration group (selection made at random), no significant differences in achievement were found on 4 course examinations.

Miller used TV instruction with six groups of college freshman chemistry students and two groups who received live lectures. No significant differences in achievement were found, but a measure of

students' attitude toward instruction resulted in significant differences in favor of live lectures.

Kurpiewski compared the relative effectiveness of four methods of lecturing on direct-current electricity with question-and-answer periods. The 833 naval trainees were divided at random into four groups, with results as follows: (1) Lectures with conventional question-answer session at the end; least effective on knowledge posttest and later retention test; (2) questions projected on a screen at the end of the lecture and trainees respond on answer sheets; no differences from group 1 on posttest, though this group was superior on retention test to group 1; (3) questions projected during the lectures after small topics completed—superior to method 1 on posttest and retention test; (4) similar to (3) above, except an electronic device was used to make responses and signal correctness of responses—largest difference on posttest and retention test of all methods.

The results indicate that uninterrupted lectures are not the most effective teaching approach, at least for these experimental groups.

Rickert compared the effectiveness of instruction in (1) a traditional physics course, (2) a survey of physical science course, and (3) a physical science course with opportunities for students to analyze problems, examine assumptions, collect and organize data, and test hypotheses. Using the American Council on Education Test of Critical Thinking, Form G, as a pretest and posttest, he found that the group in which critical thinking was stressed gained significantly (0.05 level) more than the physics group or the survey group after one semester of instruction.

Shockley used the Schaie Test of Behavioral Rigidity with a group of 90 students in a physical science class. The class was divided into *rigid* and *flexible* groups, and the groups were compared on critical thinking, skill in applying principles of physical science to new situations, and overall achievement. Analysis of covariance results indicated that the *flexible* group was superior in critical thinking, but no significant differences were found with the other measures. Assignment of homework problems designed to bring about shifts in *problem-solving set* did not result in greater gains in critical thinking and flexibility of one group of students when compared with another group receiving the usual type of homework problem.

Studies Related to Facilities and Equipment.—Studies of facilities and equipment at the secondary level have been relatively common in recent years, but similar studies at the college level have not appeared. *Kruschwitz* sent questionnaires to physics departments to determine facilities available for undergraduate research. He obtained a 60-

percent return and found that research was being done with some participation by better undergraduates in the department.

Studies Related to Teacher Education.—One of the important current problems in science education is the improvement of science teaching in the elementary grades. The primary source of the difficulty is the meager knowledge of science which elementary teachers possess.

A historical analysis of elementary teacher preparation in science by *Verrill* shows that the current problems have been in existence since 1870. The elementary science curriculum continues to lack planning and qualified teachers; State certification requirements have been of little help in promoting improvement.

Support for training of science teachers has been provided by the National Science Foundation since 1956. Few attempts to evaluate the effectiveness of summer institutes and academic year institutes have been reported to date.

Gruber found that participants in academic year institutes at Colorado made no gain in understanding the nature of scientific thinking. He concluded that a program emphasizing the products (knowledge) of science rather than the process has little effect on the teachers' gain in understanding science. Moreover, sample teaching by the participants, both at the beginning and end of the program, indicated preoccupation with known facts and principles and only seldom was an effort made "to convey a sense of the way in which scientific thought unfolds. . . ."

Parker sent questionnaires to 395 participants of summer institute programs in Louisiana and their 375 principals. He obtained a response of only about 40 percent. At that, 9 percent of the responding principals did not report that teachers were more enthusiastic in their teaching; 10 percent of the teachers indicated that their purpose for attending the institute was for the money involved (participants receive stipends of up to \$75 plus \$15 per dependent per week, tax exempt).

Some industries have regular programs of summer employment for science teachers; other companies often hire teachers on an irregular basis. *Cooper* studied the effects on science teaching of summer employment programs. He found that companies were generally pleased with employed teachers. Using a teacher questionnaire, he reported that summer employment resulted in a change in educational objectives with more emphasis placed on industrial applications, the scientific approach to problem solving, and the importance of careful planning and execution of research.

Crall and *Myers* found from a questionnaire survey of 56 colleges and universities that requirements for the master's degree in biological

sciences varied widely. Semester-hour requirements for a major in biology, botany, or zoology ranged from 3 to 36, with the average being 18. On the basis of questionnaire items and other comments, they concluded that for a biology teacher, a master's degree should include a substantial major in biology and some research experience.

The relative value of college course work was judged by Kansas high school science teachers in a study by *Novak* and *Brooks*. Questionnaires were sent to 253 teachers. A followup letter and questionnaire were sent to nonrespondents, and since the first group of returns were essentially identical to responses of the followup group, all questionnaire responses (77 percent return) were grouped together. Teachers were asked whether they felt a specific college science course was *essential*, *helpful*, or *of little value* for teaching various high school science classes. Only three elementary college science classes were rated *essential* by 50 percent or more of the respondents to teach general science, chemistry, or physics; four courses were rated *essential* for teaching biology by 50 percent or more of the respondents. Some courses were rated *of little value*, for example, to teach chemistry, physical chemistry (20 percent), and advanced chemistry (32 percent) or to teach biology, ecology (29 percent), and plant taxonomy (21 percent). It would appear that science teachers in Kansas are less convinced of the value of advanced work in science for high school teachers than college science faculties.

Studies Related to Evaluation and Research Design.—*Ried* developed an Employee Evaluation Scale for use with medical assistants. The scale was used with senior women in a medical assisting curriculum in a 2-year community college where students rated each other. A battery of tests was administered. Six months after graduation, the physician-employer was asked to rate each graduate on the scale. Using these ratings as criterion scores, *Ried* obtained a correlation matrix for the 33 test variables and found that the best predictors of success came from traits measured by the personal profile and the personal inventory tests. She concluded that measures of personality traits could be used in counseling and predicting success of future medical assistants.

In a related study, *Shadmi* gave tests of "nonintellective" variables to 286 male engineering and applied science freshmen. Using combined scores on a mathematical aptitude and a reading comprehension test as a measure of ability, *Shadmi* found Values, Achievement via Conformance, Achievement via Independence, and Need Achievement test scores correlated positively and significantly with ability and grades earned. Values showed interaction with ability with only values scores of the upper ability group correlating significantly

($r=0.53$) with achievement. A need for further analysis of possible nonlinear relationships between ability and achievement in future investigations of nonintellective correlates of achievement was suggested.

The development of a procedure to identify "research ability" was reported by *Strauss*. A group of 96 faculty members at the University of Wisconsin were interviewed for 30 to 90 minutes, using a schedule of 17 semistructured questions. Each interview was recorded and later transcribed; 151 categories of interview "elements" were established and each transcribed interview with coded "elements" noted was checked by the faculty member interviewed. Faculty members commented favorably on the coded interview transcriptions. These were then analyzed and common elements were noted. Little difference in expressed attitudes was found between biological scientists, physical scientists, social scientists, and humanists. Twenty components of research ability were identified as the most frequently mentioned: Drive or perseverance, intellectual ability, strong interests, curiosity, hard work, ability to work independently, analytic skill, imagination, and a questioning attitude. *Strauss* hopes that continued analysis of traits related to research ability can lead to the development of a paper-and-pencil test for this ability.

Interpretation

The large volume of research in the physical and biological sciences presents a striking contrast with the relative dearth of research in the teaching of science. Approximately 100 investigations were reported for 1959-61, and only 63 were located for 1961-63. Although the efforts to locate studies were probably not completely effective, it is reasonable to assume that the major part of the research has been identified. More than half of the studies were completed either for master's or the doctor's degrees. As in previous years, these have often been directed toward somewhat isolated problems.

The lack of research is especially apparent in three of the fields for investigation—philosophy and objectives, learning, and administration and supervision. The problems of scholarly analysis in the area of philosophy and objectives are many. Generalizations are often misinterpreted when applied to specific issues. Carefully prepared analyses in the area of philosophy and objectives would make a substantial contribution.

Perhaps no area of research is more important than that dealing with the analysis of the learning process. Despite recent advances in the fields of psychology and social psychology, applications of their findings are rarely found in the science education literature. A thorough understanding of the research in these behavioral sciences is a prerequisite for studies in learning. This interdisciplinary understanding is probably more important for research in learning than in other categories. The lack of this background may explain in part why so few basic studies dealing with learning in science education have appeared.

Studies Related to Public Policy.—The studies grouped in this category deal with public support of science and science education or with attitudes toward these fields. During the biennium, several studies relating to factors affecting the individual's selection of scientific or science related careers have appeared. Closely related to these are studies on the traits of scientists including analyses of their earlier training.

Studies Related to Curriculum.—Some of the studies in this classification serve special purposes in certain schools or colleges. Others were surveys of existing course offerings or patterns. The usefulness of some of the studies may be limited because of the lack of sampling information, special characteristics in the measuring instruments, distinguishing features of certain courses or course sequences, and the statistical techniques used. In most instances, the findings are restricted to the institution in which the research was completed.

Studies Related to Methods.—Teachers are constantly searching for new approaches and new devices to increase their effectiveness. Through the years a pattern of instruction has been identified. However, the limitations of this "traditional" pattern in the teaching of attitudes, appreciations, and ability to think critically have been recognized. The studies reported have compared the relative effectiveness of some of the newer instructional devices, including programmed material, television, films, and various approaches to laboratory work. Probably the greatest problem in analyzing the relative effectiveness of various teaching methods stems from the difficulty in finding suitable tests for measuring changes in attitudes and the ability to think critically.

Studies Related to Administration and Supervision.—Although problems of administrative planning for more effective science instruction are easy to define, they are difficult to solve because of financial barriers, personnel problems, and problems related to the character of the institution. The lack of studies in this category discloses a need to explore ways of utilizing staff (including assistants), facilities, equipment, and laboratory and lecture space more effectively. College personnel face these difficulties daily, but they are seldom able to plan a systematic study that would find solutions to their problems.

Studies Related to Teacher Education.—A number of the studies in this category attempt to measure the teacher's understanding of science or his change in attitude toward science. Others were concerned with professional preparation.

With a single exception, the problems of research in teacher education are the same as those in other areas. The ultimate criterion for judging effective teaching is the student's performance. Thus, ideal evaluation of an educational experience for teachers can be made only after a teacher has returned to the classroom.

Most research in teacher education attempts to measure the teacher's proficiency, not the proficiency of the students taught by that teacher. No doubt there is value in this type of analysis. One must caution, however, that higher scores made by a teacher on a battery of tests do not necessarily mean that greater pupil achievement will follow.

Studies Related to Evaluation and Research Design.—Carefully designed studies relating to measurement and evaluation are urgently needed. The shortage of studies in this category may be attributed in part to a lack of development in educational philosophy from which problems might be defined, and a need for appropriate tests or measuring devices.

Selected Abstracts—1959-61

BOTDORF, RUTH GRAYBILL. Using Filmed Demonstrations in General Chemistry.

Problem.—To determine if films can be used effectively in the classroom to show demonstrations of topics discussed in general chemistry.

Procedures.—The experiment was conducted in a first-semester general chemistry course at the Ogontz Campus of The Pennsylvania State University. The 47 students were assigned at random to an experimental group of 23 and a control group of 24 subjects.

A series of 18 half-hour kinescope recordings prepared by The Pennsylvania State University for the Department of Defense was used in about half the lectures given to the experimental group. These films heavily emphasized demonstrations. The control group received the usual classroom lecture demonstrations. Three 50-minute tests and a final examination were used to evaluate the experiment. The tests were of the multiple-choice type. The data were analyzed to obtain the mean scores on the examinations, the *F*-values, and their significance.

Findings.—The film group performed slightly better on the tests than the control group, but the differences were not statistically significant.

BRIZEE, ROBERT LOUIS. Identification as a Process in the Choice of an Occupation: A Study of the Significant Adults of Chemists and Personnel Workers.

Problem.—To determine whether scientists differ from social service workers in selected work values, and to determine

whether the scientists have identified with adults who are perceived by them to hold certain work values which are different from the work values perceived by social workers to be held by adults with whom they have identified.

Procedures.—Thirty-seven doctoral candidates in chemistry and 35 candidates in student personnel work at Michigan State University were the subjects. An interview schedule was employed and candidates were asked to select one adult whom they respected, to whom they felt close, and who was nearest to being the type of total person they wished to become. Likewise, each was asked to rank 11 work values as he perceived the adult he had chosen would rank them.

Findings.—Over one-half of the adults identified by the groups were high school teachers or college professors, and more than one-third were in the subject's occupational field. The scientists valued an opportunity to continually discover and understand why certain happenings take place in the world more than social service workers. Conversely, social service workers placed greater emphasis than scientists upon an opportunity for close relationships with others and an opportunity to help another person directly.

It was found that more of the scientists than the social service workers valued an opportunity to do work in which one excels and enjoys, while more of the social workers than the scientists valued an opportunity to do something which will ultimately benefit mankind. There was support given to the concept that scientists are less oriented toward people than social service workers. However, the concept was not supported that the members of the two occupational groups

had identified with adults having different values.

COOPER, EDWIN HALE. A Study of the Effects Upon Science Teaching of Summer Employment Programs in Industry.

Problem.—Three problems were considered: (1) To determine the objectives and practices followed in 1955-58 by representative companies in the United States in their summer employment programs for high school teachers through summer industrial employment (mathematics and science); (2) to identify and describe new or modified ideas, information, skills, and methods in science and mathematics made available by industry to teachers through summer employment; (3) to study the relationship of new or modified ideas, information, skills, and methods of teachers as determined in problem 2 with the specific objectives and practices of industry as found in problem 1.

Procedures.—The data were obtained by two questionnaires. One, designed to determine objectives and practices followed by industry in the summer employment of teachers, was sent to 104 companies throughout the United States. The other, designed to identify and describe new or modified ideas, information, skills and methods in science and mathematics made available to high school teachers through industrial employment, was sent to 125 cooperating teachers employed by industry in the summer of 1957.

A comparison was then made between the results of the two questionnaires. Certain questions and their answers were considered from the data. For example, in chapter II, the present objectives and practices of summer employment are determined. Chapter IV indicates how well the objectives of the employment programs are appreciated by the employee-teachers. Chapter V portrays the extent to which employment practices

have produced in the teachers a feeling of being more effective in the classroom. It should be noted that no attempt was made to determine how much of the data reported was actually used.

Findings.—Employers usually justify the employment of teachers to (1) improve the quality of science teaching, (2) provide supplementary income for the teacher, (3) aid industry in useful work, and (4) encourage youth through the teacher to pursue careers in science. The most important requirement of a teacher for employment is to be a college graduate with some formal course work in science. Salary is generally determined by the job. However, it is more common for those companies with regular summer programs to determine pay by taking the teacher's salary into consideration. Most companies feel they receive full value for summer salaries paid.

Summer employment caused a change in the teacher's educational objectives. More emphasis was placed on the uses of industrial applications in teaching, the scientific approach to problem solving, mathematics problems, student initiative in designing, setting up, and carrying out laboratory experiments, and in learning physical principles and theory.

Changes developed in the teacher's understanding of the scientific approach to problem solving. Some of these changes include more realization by the teacher of the importance of accuracy, the importance of the team approach to problem solving, the need for careful library research, the need to define the problem and check various ideas, and the importance of individuality to the science approach. In general, the responses of the teachers confirmed that the industrial goals of these summer teacher programs were achieved.

CRALL, H. WILLIAM, and R. MAURICE MYERS. Recommendations for Master's Degree Preparation for Teachers of Biological Sciences in High School.

Problem.—To determine certain aspects of the present status of master's degree preparation—in the biological sciences.

Procedures.—A survey was made of certain aspects of master's degree preparation in the biological sciences in 56 colleges and universities of the United States, mostly in the Midwest. The questionnaire included items about the requirement in education or psychology, the hours required for a biology major, zoology or botany major, and whether a master's degree in education was offered. The institutions were also asked to indicate if they thought a master's degree would increase earnings in larger cities. Another questionnaire was sent to the State superintendents and the chairmen of the State committees of the Commission of Secondary Schools of the North Central Association of Colleges and Secondary Schools in 12 Midwestern States. It included items about the number of specified hours, if any, a high school biology teacher should have for his master's degree, and asked whether a distinction should be made in the types of master's degrees granted administrators and subject matter specialists. Questions were included about the proper agencies for enforcing the requirements for master's degree preparation. Finally, the questionnaire sought to determine whether it is equally as important to know what to teach as it is to know how to teach, and whether salary increases should be determined, at least in part, by the type of master's degree earned.

Findings.—Most schools offering the master's degree considered that such a degree would increase the earnings of teachers in larger cities. The semester-hour requirements for a major in biology, botany, or zoology ranged from 3 to 36, with an average of 18. About two-thirds of the schools offering graduate work permit students to elect biology, botany, or zoology as a major either singly or in a combination with education. The semester-hours of professional education courses required for a master's degree

averaged nearly one-third of the total hours, leaving about two-thirds for study of biological sciences. A majority of the association chairmen and the State officers agreed that there should be a specified number of credit hours of biology for a master's degree for a high school biology teacher. Most of them agreed that there should be at least two types of master's degrees, one for the subject matter specialist, and another for the administrator. All of the officers thought that requirements of a specified number of semester-hours in biology should be enforced. Although opinions as to the agency responsible for enforcement varied, most respondents emphasized the role of the institution granting the degree. There was agreement that it is as important for a biology teacher to know how to teach as to know what to teach. A majority agreed that salary increases should be determined by the type of master's degree earned, at least in part.

DUNBAR, R. E., and J. W. BROBERG. Graduate Examination Practices at the M.A. and M.S. levels.

Problem.—To study graduate examination practices at the M.A. and M.S. levels in chemistry departments.

Procedures.—Questionnaires were sent to schools listed as having chemistry departments approved by the American Chemical Society. A total of 250 questionnaires were sent, with 84.4 percent return. State-supported, private, municipally operated, and denominational schools were included.

Findings.—(1) The use of entering or qualifying examinations is standard practice in graduate schools accredited by the American Chemical Society. (2) These examinations are usually administered before enrollment or very early in the period of graduate study. (3) Increased emphasis is being placed on undergraduate transcripts and instruction in related fields, such as mathematics, German, and physics. (4) A final com-

prehensive examination is required in the major field of study. It may be either written or oral. (5) Some schools use the *no research* or *no thesis* option at the M.A. or M.S. level.

Eliss, ALBERT F. A Study of Science Achievement of Entering Freshmen at a State College in Pennsylvania, 1958.

Problem.—To study the science background and achievement of college freshmen with respect to: (1) the science courses offered for college entrance, (2) the student's achievement in the science section of the Sequential Tests of Educational Progress, and (3) the relationships between the student's test standing and the high school science courses offered for entrance, the course of study chosen in college, and the student's sex.

Procedures.—When the Sequential Test of Educational Progress was administered in September, students were asked to fill out a form showing the courses taken in science and the number of courses taken in mathematics. The science section of the STEP test was analyzed independently by six members of the science staff at the college, and each question assigned to the categories of physics, chemistry, biology, and general science. In most instances unanimous results were obtained. When one or more of the members differed from the others, in assigning a question to a given area, the question was not considered in the tabulation. As a result, 15 questions related to physics, 11 to chemistry, and 18 to biology were selected from the 60 questions in the science section of the STEP test. The sample studied included 446 women and 306 men.

Findings.—Nearly half of the entering freshmen had taken 3 years of science in high school, and over 80 percent had completed two of the three courses commonly offered in the senior high school. When the students were classified by sex or by college curriculum, differences in achieve-

ment on the test were not significant. Comparisons of the scores on the subtests (biology, chemistry, and physics) showed little variation in achievement.

Goddard, JOSEPH PAUL. A Study of Predictive Factors Contributing to the Effectiveness or Ineffectiveness of Technical Personnel in a Selected Production Chemical Installation.

Problem.—To analyze information from the records of 170 inexperienced male bachelor-level technical employees (graduates in the physical sciences and engineering) recruited by the central technical personnel office and placed on the payroll of the selected production chemical installation between June 1951 and 1957.

Procedures.—The study was divided into two major divisions. The first dealt with the relationship of demographic data and tenure as determined by the chi-square test for the 89 of these technical employees who were still on the payroll as of June 1957, as compared to the 81 who had terminated as of that date. The second major division presented an attempt to predict performance of these 89 technical employees by using various statistical techniques to determine whether significant correlations existed between pre-selection data and performance as measured by the Performance Appraisal form.

Findings.—Four of the 16 demographic data items were significant. These were extracurricular activities, personality, part-time employment, and military experience.

It was found that there was a significance in the correlations between the professor's rating and performance. Significant correlations existed between the following pairs of factors: grades and personality, grades and professor's ratings, personality and professor's ratings, professor's ratings and supervisor's ratings, age and supervisor's ratings, grades and interviewer's ratings, interviewer's ratings and professor's ratings.

GRUBER, HOWARD E. Science Teachers and the Scientific Attitude: An Appraisal of an Academic Year Institute.

Problem.—To evaluate the first year, 1957-58, of the academic year institute at the University of Colorado.

Procedures.—During the week before the academic year began, the 53 fellows accepted for the institute took intelligence and personality tests and completed questionnaires dealing with such topics as attitudes toward science and science education and expectations about the program. During the year, sample teaching performances were given by 20 fellows. A specially constructed test on the history of science was given at the end of the year. A questionnaire dealing with views on the philosophy of science, given at the beginning of the year, was administered again in June.

Findings.—The fellows made good academic progress, though they suffered initially from disorientation caused by their sudden return to student life. Twenty-eight of the 53 who completed the year received the degree of master of basic science. The test on the history of science and the questionnaire on the philosophy of science disclosed weaknesses in the program. In the history of science test, 92 percent of the fellows performed below a standard judged to be adequate by four faculty members. No growth was observed when the results of the pre- and post-questionnaire on the philosophy of science were compared. Seldom during the teaching performances was any effort made to convey a sense of the way in which scientific thought unfolds.

HARMON, LINDSEY R. High School Backgrounds of Science Doctorates.

Problem.—To determine what can be learned about the high school backgrounds of persons earning third-level research degrees from universities of the

United States, and what implications such background data will have for the educational system at all levels.

Procedures.—The population studied was all of the 1958 graduates receiving a third-level research degree from universities in the United States. A questionnaire was sent to their high schools requesting data on grades earned in mathematics and science courses, rank in graduating class, size of class, intelligence test scores, and other information. Data were punched into IBM cards for analysis.

Findings.—Analysis was made by field, physical sciences, biological sciences, social sciences, humanities, education. Dramatic field differences were found on all variables—ability measures, geographic origins, size of high school graduating class. In general, physical sciences were highest on ability measures, followed by social sciences, humanities, biological sciences, and education (lowest). Geographically, New England and the Middle Atlantic States were in the lead, and the Deep South was far below the national average. School size was strongly correlated with doctorate productivity, except in education, with school below 100 per graduating class generally lower as doctorate origins.

HIRSCH, ARTHUR. The Research Productivity of the American-Educated Chemist in Contemporary America: An Inquiry Into Institutional Influences and Socioeconomic Factors in Relation to the Research Capacity of the Chemist.

Problem.—To study the relationship between the research productivity of chemists and (1) the class or type of school from which they graduated, (2) their highest educational attainment, (3) their economic status, and (4) the socioeconomic status of the parental home.

Procedures.—A random sample of 2,400 research scientists was selected from the *Author Index to Chemical Abstracts* for

1957 and 1958. After eliminating non-chemists, foreigners, and unqualified persons, a list of 562 American research chemists remained. A questionnaire sent to this group brought 332 usable responses.

Findings.—The survey revealed the following about the American research chemist: (1) The overwhelming majority (78.3 percent) hold the doctorate; (2) 58 percent received their undergraduate training at universities, while 42 percent attended other types of schools; (3) 45 percent graduated from publicly controlled schools; (4) only 22 percent graduated from schools lacking approval of the American Chemical Society; (5) 21 percent are employed by the U.S. Government, 29 percent are college teachers, and 42 percent are in industry; (6) the typical chemist (*a*) earns slightly more than \$10,000 per year, (*b*) comes from a better-than-average educated home, and (*c*) has a father who was either a professional man, a farmer, a craftsman, or a manager-proprietor.

KRUSCHWITZ, WALTER H. Undergraduate College Physics Research and Its Sponsorship.

Problem.—To examine the research programs of undergraduate college physics departments in an attempt to isolate some of the effects on students, faculty, and the school, with a special emphasis given to that research sponsored by an agency outside the school.

Procedures.—Two questionnaires were used: One, sent to 108 department heads who reported research being done within their group, the other sent to a random sample of 60 colleges where research was not being done in the physics department. Many of the questions were the same on both questionnaires in order to make comparisons between the two groups of schools. Approximately 60 percent of the questionnaires were returned. Comparisons were made between three groups of schools, the State, or

municipal; private, nonsectarian; and private, church related, as well as between the groups who were or were not active in research. Although as many colleges as were known to be active in research were included in the sample, descriptive statistics were used to show relations, trends, and differences because of the relatively small size of the sample.

Findings.—Undergraduate colleges reported significant research often designed to allow participation by the better students in the department. More than one-third of the researching departments took part of the work sponsored by an agency outside the school.

KUHNEN, S. MARIE. The Effectiveness of Field Trips in the Teaching of General Botany.

Problem.—To show whether the field trip was superior to the traditional laboratory in general college botany in gain in knowledge, in gain in ability to apply principles and in increase in interest.

Procedures.—The participating students were 112 freshmen or sophomore college science majors or biology minors, all taking botany for the first time. The experiment ran for three spring sessions, 6 weeks each. The rotation technique was employed. Each group was experimental for 3 weeks and control (laboratory) for 3 weeks. Four tests were given at the beginning of the experimental period: Information I and Information II, both developed by the investigator, and Application of Principles, Form 1935 and Form 1936, of the Cooperative Test Service. At the end of the first 3 weeks, Information I and Application of Principles, Form 1935, were repeated, and at the end of the second 3-week period, Information II and Application of Principles, Form 1936, were given. Snedecor's *F* score and the *t*-score were determined for all of the retest scores and test-retest scores by individual years. A questionnaire was used to determine increase in interest and other gains.

Findings.—For the information tests, of the six retest scores recorded, only one showed a statistical significance at the 5-percent level for the *F*-scores. Of the six test-retest *F*-scores, two showed a significant increase. All gains favored the control group. Of the total of 12 *t*-scores (6 retest and 6 test-retest), 6 showed a significant gain, all in favor of the laboratory group.

For the *F* test, 1 score of the 12 indicated significant gain for application of principles. This favored the experimental group. Two scores showed gains for the *t*-test for the control group. On the basis of the design of this experiment, neither the laboratory nor the field trip contributed significantly to developing the ability to apply principles.

KURPIEWSKI, BOLESLAUS S. The Effectiveness of a Modified Classroom Communicator in the Study of Learning and Retention.

Problem.—To investigate the effectiveness of the modified classroom communicator as a training aid.

Procedures.—Four procedures, three experimental and one control, were followed in presenting six lectures based on direct current electricity. The students who participated in the study were 833 trainees at the Naval Air Technical Training Center, Norman, Okla., assigned randomly to 1 of the 4 groups. The control group, method A, followed the use of conventional questions at the end of the lectures. In method B eight or nine questions were projected on a screen at the end of each lecture. In method C the questions were projected during the course of each lecture after small units of work were presented. Method D was identical to method C, except that an electronic device was used for the responses. At the end of the experimental day a posttest of 50 multiple-choice questions based on the lectures was administered. A retention test of 100 questions was given 9 days later. Analysis of vari-

ance and *t*-tests were employed in treating the data.

Findings.—The experimental methods, except for method B, were superior to the control on the posttest, and the three experimental methods were superior to the control on the retention test. Differences between the experimental methods were not significant.

LAWSON, CHESTER A., MARY ALICE BURMESTER, and CLARENCE H. NELSON. Developing a Scrambled Book and Measuring Its Effectiveness as an Aid To Learning Natural Science.

Problem.—To study the effectiveness of a scrambled book as an aid to learning natural science.

Procedures.—Ten laboratory sections in natural science, five experimental ($N=144$) and five controls ($N=181$) participated in the experiment. A scrambled version of the unit on genetics in the regular laboratory manual was prepared for use in the experimental group while the control used the original. When the unit had been completed all 10 sections were given a 30-item objective test consisting of application and analysis type of problem-solving exercises designed to measure understanding in contrast to rote memory. A questionnaire was also given to the experimental group to ascertain their reaction to the scrambled book.

Findings.—The mean score on the test achieved by the experimental group exceeded the mean score of the control group by a difference significant beyond the 1-percent level of confidence. On the questionnaire, responses indicating acceptance of the scrambled book outnumbered those indicating rejection by about 4 to 1.

LEE, EUGENE C. Career Development of Science Teachers: Personality Determinants at the Exploratory Stage.

Problem.—To investigate personality determinants associated with persons choosing science teaching as a career.

Procedures.—Two groups were selected for this study. The control group was composed of male, liberal arts graduates with degrees in science in 1960 who continued in scientific careers ($N=61$). The experimental group selected was comparable in age, type of collegiate background, type of degree, and other background variables. This experimental group, after graduating in science, chose to enter training for the teaching of science ($N=66$).

The hypotheses were analyzed in three stages. The first stage was a general multivariate test of the difference between the two groups. The second stage was a test of three areas selected for inclusion in the study: interest (from five selected scales on the Strong Interest Inventory), values (from three selected scales on the Allport-Vernon-Lindzey Study of Values), and temperament (from four selected scales on the Guilford-Zimmerman Temperament Survey). The third stage was a 1-way test of predicted differences between the two groups on each of the 12 scales selected for study. The data were collected for the experimental group during the spring and fall of 1960. The data for the control group were available from the Scientific Careers Study being conducted at the Harvard Graduate School of Education. The analysis for the first stage was a 2-group discriminant analysis using all 12 variables selected. The second stage was three two-group discriminants using the selected scales from within each area (interest, temperament, and value). The third stage was a 1-way t -test for difference of means for each of the 12 variables.

Findings.—In the general analysis, homogeneity of dispersions was tested first. The results were not statistically significant; therefore, the criterion of homogeneity of dispersion was met. A test of the difference in mean vectors was then made and the results were significant

($p<0.001$). The second stage of the analysis showed that all three of the areas (interest, values, and temperament) yielded significant differences. Their relative importance was in the order listed. The third stage of the analysis yielded 8 out of 12 correctly predicted variables with significant differences. The remaining four had no significant difference. From the analysis it was concluded that there were identifiable personality differences between those males who pursue a career in science following college graduation and those who enter science teaching. These personality traits showed the science teacher more "person-oriented", more interested in people and their problems, while the scientist tends to be "non-person-oriented" and avoids personal contacts.

McMULLEN, WARREN A. A
Study of Experiment Planning in
College General Chemistry.

Problem.—To determine the extent to which patterns of student experiment planning in college general chemistry follow a recommended pattern.

Procedures.—A recommended pattern of experiment planning, a series of five steps, was derived and incorporated into a student laboratory guide. The 1957-58 general chemistry class at Greenville College (Illinois) was indoctrinated in the use of the recommended pattern of experiment planning through the use of guides and group work in devising experiments to test hypotheses in solving four problems. Then each student was assigned a series of problems for which experiments were to be planned. The students' laboratory records were studied to derive the pattern of experiment planning used by each student for each experiment, and the derived patterns were compared with the recommended pattern.

Findings.—For the class as a whole, during the three quarters of the course following indoctrination there was no tendency to follow the indoctrinated pat-

tern more frequently than to follow all alternative patterns combined. Individual students showed wide variation in their tendency to follow the recommended pattern.

McPHERSON, CLINTON M. The Effect of Sound Motion Pictures as Measured by Differential Achievement on the Motivation of College Freshmen Chemistry Students.

Problem.—To test the effect of theoretical and enrichment sound motion picture films on freshmen chemistry students.

Procedures.—Three hypotheses were formulated: (1) that students who view sound motion picture films based on chemical theory will achieve higher grades than students who do not view the films; (2) that students who view films which show the use of chemistry in everyday life will achieve higher grades than students who do not view the films; and (3) the group viewing the theoretical films, when compared to their equated group, will show a higher degree of learning than the group viewing the enrichment films will show over their equated group.

The samples were matched on the following bases: (1) total score on the ACE psychological examination, (2) sex, (3) high school backgrounds in chemistry, (4) college curriculum, (5) textbook and laboratory manual, (6) instructors of the lecture sections, and (7) laboratory sections taught by the investigator.

Films were shown the experimental group during their laboratory sessions once a week for 13 weeks. Grades obtained from the students' hour examinations, and final grades in the course were compared by the differences of means for paired observations and equated groups, as treated by Edwards and Garrett. The value of t at the 5-per cent level of significance was used in the study. There were 35 equated pairs in the first-year group and 46 equated pairs in the second-year group shown theoretical films. There were 44 equated pairs in the first-

year group and 51 equated pairs in the second-year group viewing enrichment films.

Findings.—Hypotheses 1 and 2 were rejected because the differences were not significant at the 0.05 level of confidence. The third hypothesis could not be tested inasmuch as no gain was shown.

MEYER, HERBERT A. A Critical Analysis of the Administrative Arrangements and Classification Procedures Employed in the General Chemistry Program at the Freshman Level at the University of Nebraska.

Problem.—To compare achievement in college chemistry of students who have and have not completed high school chemistry; to determine if a prediction scheme, based on readily available factors from the student's academic background and preregistration program can be devised, and to determine whether there should be further grouping, either at the beginning of the year or at the end of the first semester.

Procedures.—Data were obtained on 860 students registered for first-year chemistry at the University of Nebraska in the fall of 1959. These data included items pertaining to high school background, college preregistration tests, and chemistry records. Achievement at the end of both the first- and second-year courses of college chemistry was compared by analysis of covariance. To study a prediction scheme, a regression equation with eight variables was first developed by dropping variables singly or in combination and evaluating the resultant losses, a prediction scheme with three variables was determined.

Findings.—This study adds one more to the many statistical studies which show that a background of high school chemistry contributes to success in freshman college chemistry. It shows that an able student with high school chemistry should achieve as much or more in fresh-

man college chemistry in a 6-hour course as an equally able student will achieve in a 10-hour course.

The significant difference in achievement between the two groups at the end of the year is largely due to difference in ability.

The study shows the need of a special accelerated course in general chemistry for the highly gifted students found to be present and for some regrouping at the end of the first semester.

The best predictors of achievement in freshman college chemistry are the chemistry pretest score, the "L" (Linguistic) score, and the high school chemistry grade.

MILLER, ADAM W., JR. The Effectiveness of College Chemistry Instruction by Television.

Problem.—To determine the effect of instruction by television on student learning, attitudes, and interests; the effect of class size on television instruction; and to compare results of standardized tests with tests developed for television studies.

Procedures.—Six experimental groups (TV) of varying sizes and two control groups (non-TV) of very small size were taught for one quarter of first-year chemistry. The students, randomly assigned to the groups, were freshmen in science and engineering curricula at Montana State College. Data were collected through objective tests of chemistry knowledge, a standardized measure of student attitudes toward varied aspects of the instructional situation, and a standardized measure of student interest in chemistry and related courses. Analysis of variance and chi-square tests were used in treating the data.

Findings.—There were no significant differences between TV and non-TV, and between large and small groups for student achievement and student interest in chemistry. There were significant differences in student attitudes in favor of the non-TV classes. Specifically, the

crucial attitude findings showed that the television instructor was considered less personable. A similar result occurred for student attitudes toward their interest and learning, and toward their motivation and effort.

NOVAK, JOSEPH D. The Use of Labeled Photomicrographs in Teaching College General Botany.

Problem.—To measure the effect of labeled photomicrographs supplied in addition to regular outline drawings in the laboratory manual on student achievement in a general botany course.

Procedures.—The experiment was conducted during the spring semester of 1958 with 43 students enrolled in general botany at Kansas State Teachers College at Emporia. The students were divided at random into two groups equated on mean scores on a biology entrance examination and the Schrammel General Abilities Test. Two treatments were used: Laboratory work with outline drawings provided in the laboratory guide, and laboratory work with outline drawings and photomicrographs. Tests were given approximately every 4 weeks and the results compared.

Findings.—In all instances the group receiving the labeled photomicrographs achieved higher test scores, but the differences were not significant.

NOVAK, JOSEPH D., and MERLE E. BROOKS. College Preparation of Science Teachers.

Problem.—To collect information regarding what high school science teachers consider necessary preparation to teach high school science.

Procedures.—A three-page questionnaire was developed listing courses that commonly appear on college transcripts of science teachers. The questionnaire was sent to 253 teachers selected at random from a list of science teachers in Kansas. The teachers were asked to indicate whether they considered each course es-

essential, helpful, or of little value. They were also asked to indicate those courses that they considered to be an *absolute minimum* needed to teach a particular science course in high school. A response rate of 77.4 percent was obtained.

Findings.—Fifty percent or more of the teachers who responded considered the following to be the minimum science requirements for teachers of high school science courses:

General Science—elementary physics, elementary chemistry, and biology;
Chemistry—one year of basic chemistry, organic chemistry, and qualitative analysis;
Physics—one year of basic physics and modern physics;
Biology—general biology (with laboratory), and physiology.

O'DOWD, D. D., and D. C. BEARDSLEE. Student Images of a Selected Group of Occupations and Professions.

Problem.—To investigate student views as to the personal characteristics and styles of life of people in various occupations, including *scientist*.

Procedures.—Interviews and questionnaires were used to study student stereotypes of men in various occupations. The questionnaire asked the respondent to rate the applicability of a series of terms to men in each of 15 occupations including scientists. The terms covered styles of life in personal and social qualities.

Findings.—Over 90 percent of completed questionnaire forms were obtained from most samples. Among students and faculty alike there was a readiness to respond to the word *scientist* in a complex and differentiated manner. There was wide agreement on the resulting image. The strong features of the image of the scientist were his high intelligence and his driving concern to extend knowledge and to discover truth. Many disturbing weaknesses in the image were reported. The scientist was seen as

basically uninterested in people and unsuccessful with them. He was viewed as uninterested in art. Further, he was considered a nonconformist and a radical, as well as one with only moderate control of his impulses. The image of the scientist was clear cut and consistent, and was embedded in a system of other stereotypes with which even educated people structure their social world.

PARKER, ALWIN. A Study of Certain Aspects of Eight National Science Foundation Summer Institutes for High School Science Teachers Conducted in Louisiana.

Problem.—To investigate: (1) the nature of the group selected for participation in the National Science Foundation summer institute in Louisiana, (2) the programs as they were handled by the colleges and universities, (3) the program as viewed by participating teachers, (4) the program as viewed by principals of the schools in which the participating teachers work, and (5) suggestions for improvement by participating teachers, principals, and institute directors.

Procedures.—Eight summer institutes were held in Louisiana (1957-1959). Questionnaires were sent to each of 395 participating teachers and 375 principals of schools in which these participating teachers work. From the teachers, 162 responses were obtained; and from principals, 137 responses. Evaluations and suggestions were obtained from each of the institute directors.

Findings.—Principal findings related to participants included: (1) 61 percent had master's degrees or earned them while enrolled as participants in the program; (2) 50 percent reported that their teaching assignment had changed after attendance at the institute, with a shift toward a full-time science teaching program; (3) 93 percent believed that they could better motivate students toward careers in science as a result of their attendance at the institute; (4) 95 percent were of the opinion that they were better teach-

ers as a result of their attendance at the institute, attributing this to an increased knowledge of subject matter in the sciences; and (5) 10 percent indicated that their purpose for attending the institutes was for the money they received, the remainder indicating that their purpose was for professional growth in the teaching of the sciences. They urged the establishment of a central clearing house for applications.

Responses from principals indicated that 91 percent believed that the participants were better teachers, were more enthusiastic in their teaching, had increased their knowledge of science, and had learned more effective use of laboratory equipment. One-half reported that the participating teachers were more active in science fairs, science clubs, and in the utilization of teaching aids as a result of institute work. They urged expansion of the program into other subject areas. All of the institute directors agreed that the primary objective of the institute was to improve subject matter competence of participating teachers.

RICKERT, RUSSELL K. The Critical Thinking Ability of College Freshman Physical Science Students.

Problem.—To compare the development of the critical thinking ability of college freshmen enrolled in three different types of physical science courses.

Procedures.—Sixty-six freshmen, all of whom were planning to be secondary school teachers, participated in the study. They were enrolled in either (1) a traditional physics course, (2) a physical science survey course, or (3) a physical science course organized to give students opportunities to analyze problems, examine assumptions, collect and organize data, and test hypotheses. Each group participating in the study had 22 students.

The critical thinking test was given during the first week and again during the last week of the fall semester of 1959. (The test used was the American

Council on Education Test of Critical Thinking, Form G.) The difference between these scores was considered to be the gain in critical thinking ability. The gains for the three groups were compared by means of the analysis of variance and the *F*-test.

Findings.—On the critical thinking pre-test, the experimental and survey groups had almost identical means, 30.3 and 30.4. The physics group had a mean of 34.7, significantly higher than for the other groups. The mean gains on this test were: physics group, 3.24; survey group, 2.00; experimental group, 6.36. The gains made by the experimental group were significantly greater than those of either of the other groups at the 0.05 level of confidence.

RIED, BLANCHE R. The Development of a Prognostic Device for Job Success of the Medical Assistant Through the Correlation of In-School Evaluations With Employer Evaluation.

Problem.—To assess the value of certain selected rating techniques which would serve as reliable prognostic indicators of success of recently graduated medical assistants in their professional employment.

Procedures.—To measure successful employment, an instrument was constructed which contained the personality, attitude, and skill traits essential to success. These traits were identified from the literature and validated by physicians and experienced medical assistants. A group of female seniors in the medical assisting curriculum of a 2-year community college comprised the population of this study. A battery of tests, designed to measure personality, attitudes, and skills, was administered to these students during their last semester. In addition, the students rated each other using the instrument constructed for this study, called the Employee Evaluation Scale. Each student received a com-

posite score, the Peer Rating score, derived from the mean of the total scores of the ratings. This same Evaluation Scale was used by two instructors to rate each student.

At the end of the fourth semester, the cumulative average for the four semesters was computed. This represented the academic achievement. The items on the battery of tests, the peer ratings, the teacher ratings and the academic achievement score represented 33 separate independent variables or predictor traits. After graduation, each student obtained employment as a medical assistant. Six months after employment in the same position, the physician-employer was given the Employee Evaluation Scale and asked to rate his medical assistant on each item. The numerical score derived from this rating constituted the criterion for this investigation.

Since success on the job was established by the employer rating scores, those in-school evaluation scores (33 variables) showing the highest validities with the employer rating score were selected as the best predictors. These scores were combined as a unit and by means of the multiple regression equation their correlation with the criterion was determined. The relative importance of each of the predictor scores in determining the criterion was established by the regression weights and the beta weights. Relationships between other traits in the correlation matrix were examined for marked high or low correlations.

Findings.—The best predictors of success came from the traits measured by the personal profile and personal inventory tests in the battery. These traits, sociability, ascendancy, vigor, and personal relations, identify the attributes of gregariousness, liveliness, and the liking of people, which are essential to the medical assistant employed in a physician's office. The other inschool evaluations (peer ratings, teacher ratings, academic achievement) showed a low or a negative correlation with the criterion.

The predictors deemed important in this study all come under the category *personality*. The importance of personality is also evident on the Employee Evaluation Scale where 10 distinct traits comprise this part of the scale, while only 6 were identified for attitudes and 6 for skills.

SHADMI, RENA M. An Investigation of the Interaction Between Selected Nonintellective Variables, Ability and Academic Achievement of Engineering and Science Freshmen.

Problem.—To explore the nature of the relationship between nonintellective variables and academic achievement.

Procedures.—The subjects were 286 male engineering and applied science freshmen. The following nonintellective variables, presumed to cover a broad range of sociopsychological content, were investigated: social class identification, interests, occupational level of interests, interest maturity, self-acceptance, achievement *via* conformance, achievement *via* independence, values, and level of vocational goal. The last two variables were derived from an especially designed questionnaire; the others were measured by standardized instruments. A combined score based on subjects' performance on a mathematical aptitude test and a reading comprehension test was used as an ability measure.

For each of the 10 nonintellective variables, analyses of variance comparing the mean grade point averages of subgroups classified on the basis of upper, middle, and lower levels of ability, and high, average, and low levels of the variable were carried out. Correlations between variables which produced significant results in the analyses of variance and achievement were computed for the three ability levels separately and for the total sample.

Findings.—The interaction hypothesis was not supported for nine variables, indicating that, in general, the relation-

ship between nonintellective variables and achievement is not likely to differ significantly from one ability level to another.

Values was the only variable which showed interaction with ability; it discriminated between achievement levels of the high ability group, but failed to show a relationship with achievement on the other two ability levels. A correlation of 0.53 between values and grades was obtained for the upper ability group indicating that intrinsic values were characteristic of high achievers and extrinsic values were characteristic of low achievers in that group. In addition to values, achievement *via* conformance, achievement *via* independence, and need achievement showed positive and significant relationships with achievement. Achievement *via* conformance was the only variable which did not correlate significantly with ability, but the other two variables retained their significant relationship with grades even after the effects of ability were controlled.

A tendency of the ability measure to predict achievement for the upper ability group and to show no relationship with achievement in the lower ability group was also observed. This finding suggests that attention be given to the possibility of nonlinear relationships between ability and achievement in future investigations dealing with nonintellective correlates of achievement.

SHOCKLEY, JAMES T. Behavioral Rigidity and College Physical Science Instruction.

Problem.—To determine whether behavioral rigidity influences outcomes of physical science instruction and to ascertain whether homework assignments consisting of multiple-approach problems facilitate greater gains in two educational skills and in flexibility than homework assignments of the usual type.

Procedures.—To attain the first objective, the Schaie Test of Behavioral Rigidity was used to select rigid and flexible groups from a physical science class of

90 students at Fresno State College. Students in these two groups were compared on several instructional factors by analysis of variance and covariance. The second objective was approached by separating random numbers. Control groups were assigned conventional homework problems for one semester, whereas experimental groups were required to do homework designed to bring about shifts in problem-solving set. Control and experimental groups were compared on instruments of measurement and evaluation by analysis of variance.

Findings.—Evidence obtained in the first part of this study indicates that flexible subjects significantly excelled rigid subjects in critical thinking, skill in applying principles of physical science to new situations, and overall achievement. However, when adjustments were made statistically to compensate for background knowledge and skills and aptitudes, only in critical thinking did a significant difference remain. The second part of the investigation disclosed that subjects who received homework assignments of problems requiring shifts in problem-solving set were no more successful in applying principles of physical science to new situations than were subjects who received homework of a conventional nature. Assignments of problems encouraging shifts in approach likewise produced no greater gains in critical thinking and flexibility than assignments of the usual type.

SMITH, ALICE CLARK. The Relationship Between Pre-College Status and Achievement in College Biology Courses by Upper Class Biology Majors at Tennessee Agricultural and Industrial State University, 1958-59.

Problem.—To determine the relationship between achievement of upper class biology majors in their major field and the following factors: (1) Number of semesters of high school science, (2) achievement in high school biology, (3)

achievement in high school chemistry, (4) intelligence quotient, (5) reading ability, (6) sex, and (7) size of high school.

Procedures.—Data were secured from the files of the university registrar, the university testing bureau, and the department of biology at Tennessee Agricultural & Industrial State University. Using the method of rank difference, correlations between the following factors were computed: (1) Achievement in freshman biology and in intelligence quotient, reading, achievement in high school biology, high school chemistry, and in upper class biology; (2) achievement in biology by students with science interests and the factors listed in (1); and (3) achievement in biology by students with nonscience interests and the factors listed in (1).

Findings.—(1) There was a significant relationship between intelligence quotient and achievement in freshman biology for seniors ($r=0.59$). However, there was a very slight relationship between the same factors for the juniors and for students with science interests ($r=0.11$ and 0.41 , respectively). A negative correlation ($r=-0.02$) was recorded for students with nonscience interests. (2) There was a significant relationship between reading score and achievement in freshman biology for both juniors and seniors ($r=0.27$ and 0.63 , respectively). For those with science interests there was a very significant relationship ($r=0.63$). For those with nonscience interests, there was an inverse relationship ($r=-0.16$). (3) For all categories of students a slight relationship was revealed between achievement in high school biology and freshman biology (r ranged from 0.11 to 0.39). (4) The correlation between freshman biology and upper biology revealed that there is a definite relationship between previous training in biology and subsequent achievement in biology (r ranged from 0.51 to 0.77). (5) The relationship between achievement in high

school chemistry and achievement in freshman biology was significant for students with science interests as well as for those with nonscience interests ($r=0.56$ and 0.69 respectively). It was not significant for juniors and seniors ($r=0.32$ for both groups).

STRAUSS, SAMUEL. High School Backgrounds of Ph. D's.

Problem.—To collect information to test a series of hypotheses regarding persons who obtained doctorates in 1957.

Procedures.—A single-page questionnaire form was mailed to the high schools of 6,938 graduates earning a doctorate in 1957. Over 90 percent of the questionnaires were returned usable. Data on size of graduating class, high school rank, grades in science and mathematics courses, and other information were obtained and summarized primarily by field of specialization at the doctorate level.

Findings.—The 6,415 usable returns provided data about 1,153 doctorates in the biological sciences, 1,935 in the physical sciences, 1,276 in the social sciences, 973 in the arts and humanities, and 1,078 in education. Virtually all of the degrees awarded were Ph. D's, except for 803 Ed. D's in education. Rank in graduating class and intelligence test scores are reported in standard scores. As indicated by high school records, wide differences in ability were found.

STRAUSS, SAMUEL. On Research Ability in Graduate Students.

Problem.—To explore the fruitfulness of a procedure for learning something about the nature of "research ability" by eliciting the opinions of persons who have had extensive experience in research and in training research workers.

Procedures.—A group of 96 faculty members at the University of Wisconsin, including the president, 4 deans, the chairmen of 13 departments, 64 full professors, and 14 associate professors were

interviewed. Of the group, 34 were in the biological sciences, 34 in the physical sciences, 15 in the social sciences, and 13 in the humanities. This body of scholars had devoted an average of 25.8 years to research and had spent an average of 17.5 years in training an average of 20.7 doctorates.

The professors were interviewed for 30 to 90 minutes, using a standard schedule of 17 semistructured questions which dealt with their backgrounds, their opinions as to the nature and component elements of research ability, and its relationship to class work, intelligence, creativity, and high school promise. Each interview was recorded and later transcribed, then analyzed for the constituent elements, which were expressed as 151 categories, grouped into 30 clusters. Each interview was then coded accordingly and the results tabulated. To check the validity of the analyses, a copy of the coded transcribed interview and the tabulated summary was sent to each subject for criticism.

Findings.—The most significant finding was that, on the points covered in this study, there was little difference in the attitudes between biological scientists, physical scientists, social scientists, and humanists. Their common interests and experiences in research and in training research workers far outweigh the differences in interest in their fields of specialization and in the traditions of their disciplines.

According to the testimony, secondary schooling did not play the dominant role in the selection of careers in science. Their undergraduate and graduate school experiences were far more vital in influencing their choice of vocations. Even more important was a gradual and general growth in interest in certain areas which they did not feel could be properly ascribed to any educational institution.

There was general agreement that research ability is a very important trait, but is difficult to define and varies greatly among graduate students. Among 20 components clearly identified, the

most frequently named were drive or perseverance, intellectual ability, strong interests, curiosity, hard work, ability to work independently, analytic skill, imagination, training, and a questioning attitude.

TUCKMAN, JACOB. Science Background of Liberal Arts Graduates.

Problem.—To compare the science background of prewar and postwar college graduates with respect to their high school preparation in the natural sciences.

Procedures.—The high school backgrounds of 222 men in the 1941 college class and 212 men in the 1954 college class were compared. Information about science courses in high school and in college were obtained from official college records.

Findings.—Of the 1954 class, 79 percent had completed 3, 4, or 5 years of work in the natural sciences in high school while 60 percent of the 1941 class had completed less than 3 years. The median number of years of science completed was 3.09 for the 1954 class, and 2.34 for the 1941 class. Ninety percent of the 1954 class compared with 27 percent of the 1941 class had completed general science. Seventy-three percent of the 1954 class compared with 51 percent of the 1941 class had completed chemistry. Fifty-six percent of the 1954 class compared with 33 percent of the 1941 class had completed physics. Of students electing regular departmental courses in science, 8 percent did not have a course in biology in high school or in college, 14 percent had no chemistry, 34 percent had no physics, and 9 percent had neither chemistry nor physics in high school or college. The science background of postwar liberal arts graduates suggests, in contrast to the trend demonstrated for unselected high school students, that students enter college with a better preparation in science, especially in the physical sciences than did those in the prewar period. The data also suggest that stu-

dents fail to round out their science preparation in college, but rather tend to choose the same courses taken in high school.

TUCKMAN, JACOB, and WILLIAM ETKIN. The Relationship Between Science Proficiency and Training Among Liberal Arts Graduates.

Problem.—To compare the proficiency in science, as measured by the Graduate Record Examination, of the City College graduates who had completed a science sequence and those who had completed regular departmental courses.

Procedures.—At the College of the City of New York, a student in liberal arts may fulfill the science requirements for the bachelor's degree by completing two 1-year courses offered by the regular departments or by completing four one-semester courses called *science sequence*. In the *sequence*, physics is offered in the first semester, chemistry in the second, biology in the third, and astronomy and geology in the fourth.

GRE scores were available for 24 students who had elected the *sequence* and 123 who had elected regular departmental courses. The comparison between *sequence* and *regular* students was made by the paired comparison method. The two groups showed no significant differences in their overall college averages.

Findings.—Comparisons of the regular students grouped according to the science course taken in college showed that, in general, those who had taken a regular (1 year) course scored higher on the GRE than those who had taken the *sequence* (1 semester) course in that subject. Correspondingly, those enrolled in the *sequence* course scored higher than those with no college course in that subject. Those who had completed a high school course in a subject had a higher score than those with no high school or college course in that subject.

The data showed a tendency for the score on the GRE to be affected by the extent of the student's course prepara-

tion. Comparisons between total groups of *sequence* and *regular* students showed no significant differences in mean score for physics, chemistry, or biology.

VERRILL, JOHN EARL. The Preparation of General Elementary Teachers to Teach Science: 1870 to the Present.

Problem.—To study the preparation of elementary school teachers in relation to science subject matter, methods and materials courses, student teaching experience, and inservice education opportunities from 1870 to 1959.

Procedures.—Historical data were gathered from theses, methods books, courses of study, association yearbooks, and educational historical sources. A questionnaire was sent to teacher education institutions in six States to determine present practices in preparing elementary school teachers to teach science.

Findings.—On the basis of the study reported, it would seem that elementary teachers have been poorly prepared to teach science. All evidence indicates this was true for the entire period investigated. Since the scope, sequence, and objectives of the science program for the elementary grades have never been clearly defined or agreed upon, the types of program needed to prepare the teachers have lacked clarity, direction, and a definite goal. Elementary teachers had been better prepared to teach the life sciences than the earth or physical science aspects of the program. The time devoted to attaining science subject matter background had not increased in proportion to the overall time increase for preparing elementary teachers.

Most prospective elementary teachers acquired science subject matter through general education courses, or basic courses for science majors rather than courses designed to meet the unique needs of the elementary teacher. The professional methods class for teaching science in the elementary school varied

greatly. The instructor in professional methods rarely supervises his students in their student teaching experience. Very few institutional or state requirements made it mandatory for the elementary student teacher to teach any science

as part of the student teaching experience. The two most prevalent inservice opportunities offered to experienced teachers for improving science instruction were summer school classes and curriculum libraries.

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Guidelines and Recommendations

FREQUENT REFERENCE has been made throughout this bulletin to the improvement of research in science teaching. Two overriding issues appear to be involved in improvement of research: An increase in quantity, and the improvement of quality.

An increase in the number of research studies in science education will not improve existing conditions unless there is accompanying improvement in the quality, depth, and nature of the problems selected. During the biennium of 1959-61 included in this report, the largest number of studies (more than 200) reported were at the secondary level. When one considers the existent issues and problems and the need for basing a program in science teaching on knowledge that has been established and tested by research, he wonders about a research endeavor that produces an average of about 100 studies per year at the secondary level.

If research in science education is ever to reach a preferred position in the profession, the present trend of merely doing research for advanced degrees must be reversed. Research to discover evidence on basic issues and problems must have priority over the research of incidental problems.

In this incidental research at least three difficulties are immediately apparent. First, the typical graduate student has only a limited amount of time. He is under pressure to complete his study so he can move on to full-time teaching (and hopefully additional research). Second, student-conducted research generally suffers from a lack of resources, particularly a lack of financial support. In many instances inadequate sampling techniques are used simply because of the prohibitive cost of extending the study to a larger universe. The result is that the problem selected is usually catch-as-catch-can, and highly local in nature. Further, it is unrelated to any pattern or plan stemming from hypotheses derived from educational theory or from unresolved issues. It is probably true that the student has developed useful research techniques, but the value of the study has necessarily been limited. In addition, one may question the economic efficiency of the time invested in the research undertaking. Finally, faculty time for proper direction and supervision of graduate research is generally not available. Virtually all of this research is supervised by persons carrying a substantial teaching assignment in addition

to their responsibility for directing research. Cooley has pointed out, "Research is not something someone sandwiches in between a multitude of other activities. It is a fulltime job; and we cannot expect to get the competent research we sorely need until such men are on the staffs of every graduate program in science education."¹

Identifying the shortcomings of the current research and problems embodied in these shortcomings is a necessary step in the process of improvement. It must be followed by constructive suggestions if positive results are to be expected. The following, although not an exhaustive or complete list of such proposals, may suggest additional specific steps:

1. Research in science education must emerge from and contribute to the extension of sound educational theory. Implied in this is the idea that science education research must take cognizance of and build upon research in related fields. Basing research only on past efforts within the field of science education will continue present entrenchments and foster efforts on insignificant and peripheral problems. Related fields in the behavioral sciences contribute not only basic theory but also refined techniques to research in science teaching.

2. Science education researchers need to encourage an attitude of criticism. A comparison of the research endeavor in science education with that in science discloses a marked difference in the atmosphere of self-criticism. In all too many instances the findings of science education research are accepted without examining the way in which the findings were derived. The underlying assumptions are rarely analyzed, and the appropriateness of the research design is seldom questioned.

3. Research efforts should be directed more toward significant problems of science teaching. The importance of science and technology in our society has already placed new demands on the schools. There is a related and compelling need for the research enterprise in science education to direct its efforts toward the solution of problems of teaching and learning. Devoting time and effort to peripheral problems does not hold promise for strengthening the instructional program.

4. Careful attention should be given to the design of the research study. It would be difficult to replicate many of the studies reported in this bulletin. The reasons which hinder replication emerge from several sources: The problem may be poorly defined; the sample may be too small or not representative; or the findings do not follow directly

¹Cooley, William W. Challenges to the Improvement of Science Education Research. *Science Education*, 45:383-387, December 1961.

from the data. The need for well-designed studies directed toward solving significant problems cannot be overemphasized.

5. Science teaching centers are now established or are being developed at more than 30 colleges and universities in the United States. While these vary in organization, staff, and budget provision, all are devoted to the problems of improving the teaching of science. These centers could become a pervasive influence for the improvement of research in science teaching if it were possible to provide a staff of competent researchers at each center. In such a plan staff members would be expected to spend a certain proportion of their time in conducting research, a part in directing the research of graduate students, and a part in teaching and other associated duties.

A given center might spread its research efforts over the entire spectrum of issues in science teaching. There might be other centers where the staff would choose one or more issues around which the research of the center would be conducted. Such a center could go a long way toward creating an environment for young teachers in training that would make them lifelong researchers as they enter teaching. The contagion of a teacher who is motivated to continue research on the job can be transmitted to his students. Problems met by teachers in the classroom might furnish the basis for additional research at the center.

Classification of Research Investigations

At the 1953 meeting of the National Association of Research in Science Teaching, the committee on research presented the criteria listed on page 142. These criteria have been used by the committees who have cooperated in the collection and analysis of science education research. At the 1961 meeting a panel of the Association discussed a different scheme of classifying studies and presented papers describing four types of investigations:

1. Surveys and Status Studies ¹
2. Analytical Surveys ²
3. Experimental Studies ³
4. Curriculum Research ⁴

¹ Obourn, Ellsworth S. Surveys and Status Studies. *Science Education*, 45: 391-393, December 1961.

² Anderson, Kenneth E. Analytic Surveys. *Science Education*, 45: 412-417, December 1961.

³ Pella, Milton O. Criteria for Good Experimental Research in the Teaching of Science. *Science Education*, 45: 396-399, December 1961.

⁴ Barnes, Cyrus W. A Definition of Science Education: Curriculum Research, *Science Education*, 45: 394-396, December 1961.

Since the meeting, a committee of the Association has worked to develop a revised set of criteria for research in science education. The efforts of this committee in refining the criteria to be used for each of the investigation types may result in some improvement over the older method.

A second session of the 1961 meeting was concerned with a discussion of unresolved issues in science education. The list of 76 issues that follow were presented and accepted at that time. The statements are included here as a means of suggesting problem areas for research. The issues as stated should not be interpreted as individual problems but rather as "fields for investigation" from which hypotheses may be derived and tested by appropriate research.

Fields For Investigation

I. Philosophy and Objectives

- ✦ What factors determine the place and function of science education in a democratic culture such as ours which is highly dependent upon science and technology?
- ✦ What should be the place of science courses in relation to other courses and cocurricular activities in the school curriculum?
- ✦ What are acceptable and realistic purposes for the total science program and for the different levels?
- ✦ How should the purposes of general education and specialized education in science influence the selection and organization of content and the teaching methods at the different levels?
- ✦ What science concepts, principles, skills, attitudes, and appreciations should be acquired by all pupils? By pupils with aptitudes to pursue specialized courses in science?
- ✦ What are the relative merits of various approaches such as basic science, applied science, and solving community and personal problems, in achieving the accepted objectives of science instruction?
- ✦ To what extent should process outcomes of science education such as modes of scientific thinking, attitudes, interests, and appreciations be made an integral part of teaching and learning of science?

II. Public Policy

- ✦ What level of scientific literacy is essential for intelligent, responsible citizenship in our democratic society?

- ✦ To what extent are current programs directed toward the improvement of science teaching achieving their purposes in terms of the long-range needs for scientific manpower?
- ✦ How can procedures for identifying, encouraging, and developing science talent be improved to provide more adequately for present and future manpower needs?
- ✦ To what extent is science of such importance to the national welfare that action programs are required which are directed toward improving the status, prestige, and salary of science teachers?
- ✦ To what extent should changes be made in the school science program to provide for the impact of scientific and technological advances and the accompanying demand for new and different specializations?
- ✦ Does the public interest demand that there should be a national curriculum or national standards in science?

III. Curriculum

- ✦ What are the basic science concepts, principles, intellectual and manipulative skills, attitudes, and appreciations essential and appropriate for the achievement of the accepted objectives for science teaching at each level of instruction?
- ✦ What criteria should be used in the selection and organization of learning experiences to achieve the accepted objectives at each of the levels of instruction?
- ✦ What criteria should be used in evaluating the place and the contributions of cocurricular experiences for effective science learning at the different levels and to pupils of differing abilities?
- ✦ How should each of the several kinds of out-of-class experiences be organized and conducted to make optimum contribution to learning in science?
- ✦ How can the learning experiences in science in a K-12 program be effectively organized and/or integrated at each level to follow logically and sequentially from the preceding level and be articulated so as to contribute to the following level?
- ✦ How can firsthand experiences in science be organized, scheduled, and conducted to contribute maximally to the understanding of science concepts and principles and to the development of the modes of scientific thinking?

- + What is the optimum amount of time which should be provided for science instruction in elementary, junior, and senior high school levels in terms of their objectives?
- + Should applied science topics or courses such as consumer education, conservation, aeronautics, electronics, physiology, and health education be incorporated in the general education program in science? If so, what are some of the effective ways of incorporation?
- + Should science learnings be integrated into a core curriculum or should they be taught in separate courses at different grade levels?
- + How can the results of science education research on curriculum problems be more effectively interpreted and disseminated so as to result in the improvement of the science curriculum at each level?
- + How can the solution of curriculum problems in science at the elementary and secondary levels be sought within the spirit, structure, and function of science?

IV. Learning

- + What are the psychological characteristics of pupils of different types and varying abilities? What implications do these have for different curriculum organizations and instructional methods in teaching science?
- + What manipulative and intellectual skills are conducive to learning in science? What are the most effective ways of developing these skills? What implications do these ways have for curriculum organization and for sequence of learning experiences in science?
- + What light do current theories of learning throw on our knowledge of *concept formation*, *inductive-deductive reasoning*, and *generalizing*? What are the implications for curriculum organization, instructional methods and evaluative procedures in science at each level?
- + What are the elements of creativity, and what are their relationship to learning in science?
- + How are appreciations in science developed, and what implications do these processes have for learning in science?
- + What characteristics of attitude development relate directly to problem-solving behavior in science? What implications do these have for curriculum organization, instructional methods and evaluative procedures?

- + What are the differences in the abilities of pupils at different maturity levels to engage successfully in different modes of scientific thinking, e.g., problem solving, inductive and deductive thinking and hypothesizing? What are the implications for curriculum organization, instructional methods, and evaluative procedures in science at each level?
- + How can the results of science education research on learning be more effectively translated into the improvement of instructional and learning processes at each level?

V. Methods

- + How can the methods of science teaching be made more effective in implementing learning experiences in such areas as concept development, modes of scientific thinking, creativity, attitudes, and appreciations?
- + What are the most effective methods of helping students of varying abilities at different levels achieve the objectives of science instruction?
- + What methods can be used to develop various modes of scientific thinking at different levels?
- + How can teaching aids, such as television (both open and closed circuit), radio, films, film strips, slides, teaching machines, newspapers and periodicals, be used most effectively to achieve the objectives of science teaching at each level and for pupils of varying abilities?
- + Should methods of instruction in science for noncollege bound students differ from those for students who will pursue formal education beyond the high school?

VI. Facilities and Equipment

- + What facilities, equipment, and instructional materials are essential, or desirable, to enable pupils to have firsthand learning experiences in science for each grade level? For different levels of ability within each grade?
- + What facilities and equipment are essential (most appropriate or desirable) for each grade level for developing understandings of important principles of science? For developing desired skills in manipulation of materials and apparatus? And for developing a working knowledge of, and ability to use, the methods of science?

- ✦ What new types of facilities and equipment are needed for demonstration and for individual experimentation in the newly developed areas of science such as nuclear physics, radioactive isotopes, antibiotics, and space technology? In the recently developed experimental courses in physics, chemistry, and biology?
- ✦ To what extent should science facilities for different levels be planned and equipped for effective utilization of different types of learning in science, such as first-hand experiences through laboratory work? Through individual and group projects? Through use of mass communications media and/or audiovisual aids?
- ✦ What provisions should be made in planning and equipping science facilities for each level, which will make it possible for teachers and pupils to engage in individual and group projects such as constructing homemade devices, apparatus, and displays?
- ✦ What are the most desirable specifications for a multipurpose (all-purpose) laboratory in which all sciences may be taught, for a junior high school? For a senior high school?
- ✦ Should lists of basic laboratory experiences for each level of science instruction (or for each science course) be developed and supplemented by minimum lists of equipment and supplies required to meet the basic laboratory requirements in the course?
- ✦ What criteria should be used in evaluating the adequacy of science facilities for each level: elementary, junior high school, and senior high school?
- ✦ What criteria should be used in determining the use of textbooks, workbooks, and laboratory manuals in science instruction for the achievement of the accepted objectives at each level?
- ✦ How can local, State, and Federal funds for the construction of facilities and the purchase of equipment and materials for science instruction be expended in such a way that maximum improvement of learning will be realized?
- ✦ What is the role of professional organizations in assisting teachers, supervisors, and administrators in selecting and in making effective uses of scientific materials and equipment?
- ✦ To what extent should teachers and pupils be encouraged to design and develop pieces of apparatus and equipment used in the classroom and laboratory when such items are commercially available?

- ✦ How can school systems be aided and encouraged to develop procedures for keeping science apparatus and materials up to date and adequate in quantity and variety?
- ✦ How and by whom, can knowledge about the nature and arrangements of science facilities be introduced into the planning and construction of new school plants?

VII. Administration and Supervision

- ✦ To what extent is curriculum revision the responsibility of general curriculum supervisors, science educators, science consultants, science teachers, scientists, and laymen?
- ✦ What administrative provisions should be made to give science teachers adequate time for preparation for laboratory work, for conferences with pupils, and for sponsoring such extra-class activities as clubs, seminars, symposia, etc.?
- ✦ What types of groupings of pupils are most effective for science instruction?
- ✦ What administrative procedures and practices are most effective in recruiting and retaining the best qualified science teachers?
- ✦ What administrative procedures are most effective for providing sufficient time for adequate instruction in science at different school levels?
- ✦ What administrative and supervisory procedures are most effective in implementing the general education program in science at each level?
- ✦ What supervisory and consultant practices are most effective in improving science instruction?
- ✦ Should policy-making groups be organized and/or used by administrative officials in planning for the improvement of science instruction?
- ✦ How can administrators make modifications in the organization and operation of the total school enterprise so that a science program can be developed which really provides sequential and cumulative learning experiences for students?
- ✦ What valid and reliable instruments or techniques are available at the present time for the administrative evaluation of the total science program? What new instruments should be developed to assist the schools in such evaluation?

- ✦ What administrative procedures are most effective in motivating the community, parents, and pupils to desire a science program of high quality?
- ✦ What administrative supervisory and counseling procedures are most effective in the identification of, and provision for individuals with scientific potential?
- ✦ Can the accepted objectives of science instruction for the elementary school be realized more effectively through the use of specialized teachers or through the regular teacher?

VIII. Teacher Education

- ✦ What constitutes an adequate academic preparation and preservice teaching experience for effective teaching in science in terms of the accepted objectives at different school levels?
- ✦ What should be the nature of inservice education programs for teachers of science at different school levels?
- ✦ What modifications in college science courses should be made to assure adequate preparation for teachers in both the content and the processes of science?
- ✦ What should be the nature of the preparation of district, county, and State science supervisors?
- ✦ What experiences in experimental scientific research should be provided in the education of science teachers?
- ✦ What should be the requirements for certification of teachers and supervisors of science at each level of the school program?
- ✦ What are the responsibilities of science teachers in the area of student guidance and counseling and what preservice and inservice preparation is most effective in preparing teachers to meet these responsibilities?
- ✦ To what extent do academic year and summer programs designed to broaden and up-date the teacher's background in basic science provide for the continuing improvement of science teaching?

IX. Evaluation and Research Design

- ✦ What applications of various techniques and procedures of evaluation will lead to improvement of instruction and learning in science at different levels?

- ✦ How can we determine the effectiveness with which science concepts, principles, manipulative and intellectual skills, and attitudes are acquired by pupils at different levels?
- ✦ What are the basic principles of learning that have implications for evaluation in science at different levels?
- ✦ How can appropriate procedures be developed to evaluate and compare the performance of students in various types of curriculum adaptations such as multiple track programs, honor courses, and advanced placement programs?

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Form Sec-4 (60)

Appendix

Budget Bureau No. 51-8171.7
Approval expires 6/30/61

SCIENCE EDUCATION RESEARCH
ABSTRACT REPORT
to the
U.S. OFFICE OF EDUCATION
and the
NATIONAL ASSOCIATION FOR RESEARCH IN SCIENCE TEACHING

Instructions: Please return one copy for each research study on the teaching of science, science education or related problems completed in the biennium July 1959-July 1961. Additional forms will be supplied upon request.

This is an invitation to submit abstracts of published and unpublished studies in science education for possible inclusion in the U. S. Office of Education Biennial Analysis of Research in the Teaching of Science. For inclusion in the survey a study: 1. must be abstracted in the form suggested below; and 2. must identify a specific problem in science education for which valid data have been collected, and these data must be organized and treated so as to justify the conclusions and recommendations.

If no research in science education was done, please check and return ☐.

1.

Investigator(s) _____	Address _____
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2. Title of study: _____

3. Institution where study was made: _____

4. Date when study was completed: _____
5. Thesis? Yes ☐ No ☐ If yes, indicate degree: BS ☐; AM ☐; MS ☐;
Ed.D ☐; Ph.D ☐;
Other than thesis (specify): _____ Other degree (specify): _____
6. The report of this study is available: in published form under own title ☐; in published form under other title ☐ Specify title _____;
on microfilm ☐; on library loan ☐;
Other source (specify): _____
Available from: _____
(Organization, institution, or individual)
7. Areas of science involved:
Elementary Science ☐; General Science ☐; Biology ☐; Chemistry ☐;
Physics ☐; Physical Science ☐; Earth Science ☐;
Other (specify): _____
8. Grade level(s) involved (Circle all that apply):
K 1 2 3 4 5 6 7 8 9 10 11 12 Jr. College College Graduate

ABSTRACT OF STUDY (Not to Exceed 500 Words)

The Problem: (Not necessarily title entered in 2 above)

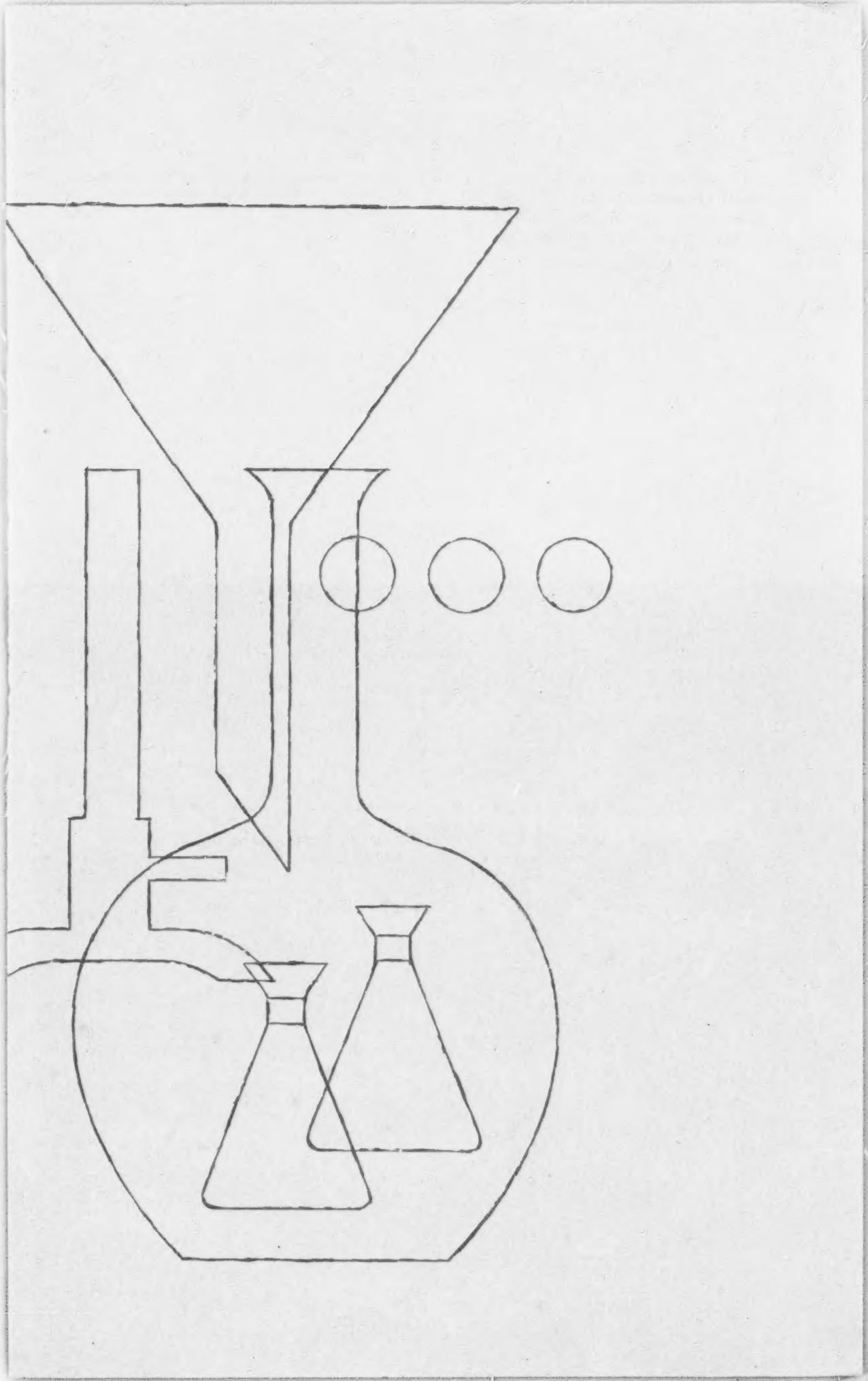
ALL ABSTRACTS MUST BE TYPED. DO NOT USE ANY OTHER FORMAT
Type on this form

Procedure: Method and Research Design: Describe as many of the following as apply to this study: (1) Hypotheses tested; (2) Experimental Design (controls, etc.); (3) Nature of sample; (4) Method of data collection, (test, questionnaire, observation, interview, etc.); (5) Statistical treatment of data (procedures, tests of significance, etc.); (6) Analytical procedures.

Findings: (Summary of data)

Conclusions:

Recommendations:



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Research
IN THE
Teaching of Science

